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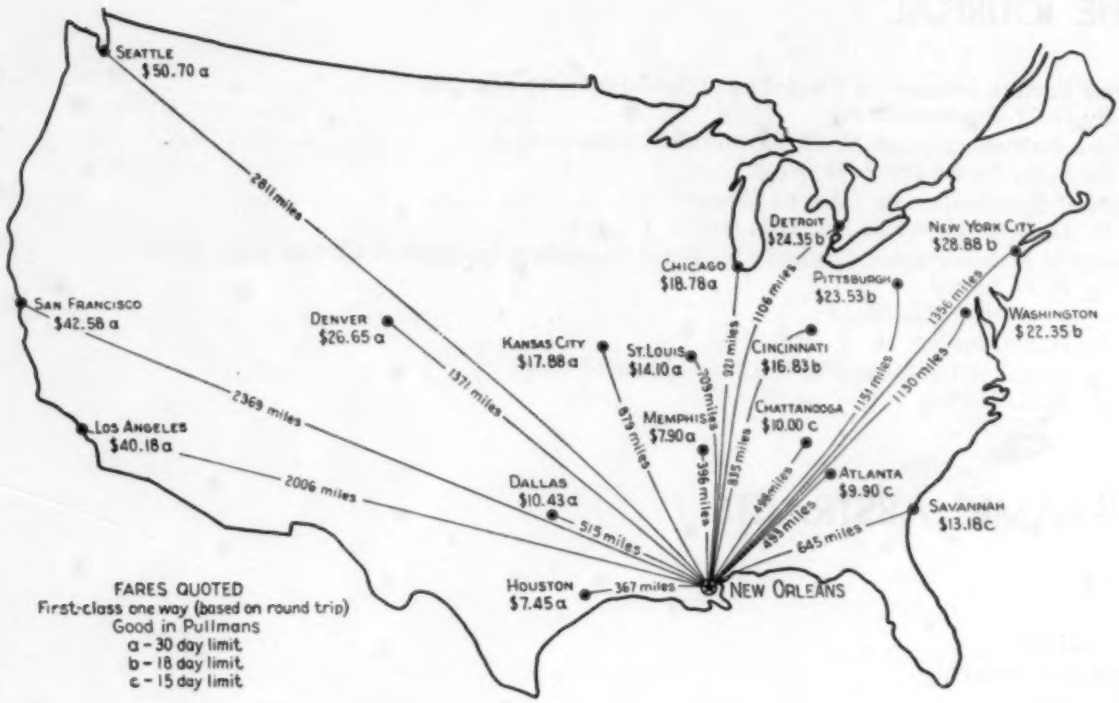

March 27-April 2, 1938

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SOME FACTORS INFLUENCING PROPERTIES OF ACID-RESISTING ENAMELS*

By G. H. Spencer-Strong

Abstract

The effect of metal gage, firing treatment, drying method, application methods, and base-coat compositions upon acid resistance and other physical properties, both alone and in combination, was determined upon three acid-resisting enamels of widely varying types. The firing treatment and application method, especially in combination with the metal gage, were found to affect acid resistance, while all of the other factors affected physical characteristics. The type of enamel and application method controlled the degree of the effect of the factors. Dust coats were found to be more sensitive to variable factors of production than heavier applications.

I. Introduction

The rapid expansion of the enameling industry in recent years has brought with it many new uses for porcelain enamels of all types. Especially has this been true in the case of acid-resisting enamels. Many enamelers who previously had little use for this type of enamels have begun to use them in increased quantity. At the same time, many of the new uses for enamels require acid-resistant finish coats. Present requirements not only call for acid resistance but for increased opacity, maximum economy of application, improved physical qualities, and greater freedom from defects.

In view of the increasingly greater number of problems being advanced in connection with the use of acid-resistant enamels, it was believed advisable to undertake an investigation of the subject covering the field as broadly as possible.

II. The Problem

The relative resistance to acid of sheet-iron cover-coat enamels has, in the past, been classified as stainless-to-acid, acid-resisting, and non-acid resisting. The acid-resisting enamels may be further classified as superopaque, opaque, and clear, although to date the superopacity is purely a relative term and not to be compared with the superopaque nonacid-resisting enamels.

The enamel may be applied directly over the ground coat, as a second coat over a fired nonacid-resisting first coat, or as a thin finish coat (or dust coat) over either a fired or a wet second coat of nonacid-resisting enamel. The weight of the acid-resisting and of the nonacid-resisting coats and the gage of the metal used may vary. Various combinations of types of acid- and non-acid-resisting enamels may be used. The specific gravity of the enamels as applied as well as the drying and firing treatment may differ. All of these factors may affect not only the acid resistance of the finished product but the other physical characteristics, such as opacity, freedom from defects, and hardness. Because, in the finished product, these characteristics are usually of equal importance with acid resistance, they must be carefully considered in any study of acid-resistant enamels.

III. Scope of Investigation

The present paper is concerned only with the general preliminary investigation of the effects of as many as possible of the various factors affecting acid-resisting enamels in service at room temperatures, not only from the standpoint of acid resistance but of the effect on physical properties as well. The investigation was designed to act as a guide in more comprehensive investigations of the various phases of the subject, rather than as a comprehensive study of every ramification of the problem, and it should be so considered. It is hoped, however, that this study may be of some aid to users of acid-resisting enamels in considering present problems and new applications.

IV. Previous Investigations

The study of the various problems involved in the use of acid-resisting enamels is not new; in fact, some of the earliest papers presented before the Society, which dealt with enamels, were concerned with acid-resisting enamels. Most of these papers related to problems of composition, application, and consistency of the slips. There were also a number which dealt with the progress of a search for a suitable test method, a search which has continued up to the present time. In fact, the proper coördination of much of the available data is made difficult by the lack of a standard test method.

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 23, 1937 (Enamel Division).

As a part of its 1936 program, the Committee on Standardization of Tests of the Technical Research Section of the Educational Bureau of the Porcelain Enamel Institute began work, in coöperation with the National Bureau of Standards, upon the specification of a standard procedure for testing acid resistance. The findings of the Committee will soon be published in the form of a tentative specification.[1]

A complete review of the literature pertaining to this subject is not believed to be necessary; an excellent review is already available in the writings of Andrews[2] and in the recent reports, Committee on Standardization of Tests of the Enamel Division, American Ceramic Society.[3] A considerable part of the literature deals with frit composition, a subject which is not pertinent to the present discussion.

It will suffice here to quote the findings of Andrews,[2] who concludes that the composition of enamel, firing time and temperature, and mill additions may influence acid resistance considerably, while, in his belief, fineness of grinding, methods of application, and drying are unimportant from the standpoint of acid resistance.

V. Outline of Investigation

(1) Enamels

For the purposes of the investigation, three commonly used acid-resisting enamels of widely different composition and physical characteristics were used. These will be referred to throughout the paper as follows:

(A) High opaque, stainless to acid: P.E.I. rating, A.*
(B) Opaque, stainless to acid: P.E.I. rating, A.*
(C) Clear acid resisting: P.E.I. rating, B to sub-B.*

* For description of P.E.I. acid-resistance ratings see Part VII, Section 2 (p. 4).

[1] Reports of Committee on Standardization of Tests, Porcelain Enamel Institute, 612 N. Michigan Ave., Chicago, Ill.

(*a*) W. N. Harrison, "Outline of Preliminary Work on Test for Acid Resistance" (manuscript, June 10, 1936).

(*b*) Rept. of Comm. on Standardization of Tests, Porcelain Enamel Institute, "Test for Acid Resistance of Porcelain Enamels, a Tentative Standard," (March 6, 1937).

[2] (*a*) A. I. Andrews, "Development of Acid-Resisting White Sheet-Iron Enamels," *Jour. Amer. Ceram. Soc.*, **13** [6] 411–26 (1930).

(*b*) A. I. Andrews, "Acid-Resisting Cover Enamels for Sheet Iron," *Univ. of Ill. Eng. Expt. Sta. Bull.*, No. 201 (1929).

(*c*) A. I. Andrews, Enamels, pp. 182–200. Twin City Publishing Co., Champaign, Ill., 1935.

[3] Report of Enamel Division Standards Comm., 1932; Sub-Rept. by Murray C. Gautsch, *Bull. Amer. Ceram. Soc.*, **11** [5] 134–38 (1932).

Report of Enamel Division Standards Comm., 1936, *ibid.*, **15** [8] 276–88 (1936).

The mill formulas used were those recommended for general practice and were as follows:

Frit	100 lb.
Vallendar clay	4 "
Tin oxide	6 "
Ammonium carbonate	4 oz.
Water	35 lb.

The enamels had a recommended maturing time of 2 minutes at 1525°F on 20-gage iron.

The following nonacid-resisting enamels were also used in the investigation:

(D) Superopaque cover coat.
(E) Opaque cover coat.
(F) Opaque cover coat.
(G) Superopaque cover coat.
(H) Superopaque cover coat.

Enamel (D) was used as the base enamel for most of the investigation; (E) was used for the investigation of the effect of base-coat weights. All nonacid-resisting enamels were used to test the effect of base-coat composition on acid-resisting enamels. A common commercial ground-coat formula was used in all cases.

(2) Metal Gage

Enamels were applied to 4- by 6-inch test plates of 12-, 14-, 16-, 18-, 20-, and 22-gage. In portions of the investigation where all gages were not used, 18- and 20-gage metal was used.

(3) Application

Acid-resisting enamels are commonly used on the ground coat, as a second coat over a fired base coat, and as a dust coat over a wet second coat. Investigation showed little difference in general behavior between the enamels applied over the ground coat or as a second cover coat over a fired nonacid-resisting base coat, except for defects introduced from the ground-coat defects. For this reason, in most of the work requiring heavy coatings of acid-resisting enamels, the enamels were applied as a second coat over a nonacid-resisting base coat.

Application, as hereinafter used, will be understood to refer to combinations of application weights and condition of base- and acid-resisting coatings, such as fired, wet, dry, etc., rather than to the physical method of application which was by spraying. Numerous combinations of application conditions were used in the study, together with various metal gages and firing and drying treatments. These are shown in the outline of the investigation.

(4) Firing Temperature

Using a base time of two minutes, firing temperatures were varied from 1475° to 1575°F in 25° increments, except in the case of dust coats over wet second coats, where the increments were 50°F.

(5) Firing Time

Using a base temperature of 1525°F, a series of firing schedules was worked out for the various gages of metal. Time No. 3 was the base or average rate. The schedule is shown in Table I.

TABLE I

FIRING TIME SCHEDULE

Time No.	Time (min.) for metal gage of 12	14	16	18	20	22
1	8	6½	4½	3½	2¾	2½
2	7	5½	3¾	3	2½	2¼
3*	6	4½	3	2½	2	1¾
4	5	3½	2¼	2	1½	1¼
5	4	2½	1½	1½	1¼	1

* Base rate.

(6) Specific Gravity

For determination of the effect of the specific gravity of the milled enamel upon the properties, enamels were applied at the maximum and the minimum workable specific gravities. These, together with the specific gravity at which the enamels are normally applied, are given in Table II.

TABLE II

TABLE OF SPECIFIC GRAVITIES

Enamel	Max. workable specific gravity	Min. workable specific gravity	Normally used specific gravity
(A)	2.108	1.914	1.94–1.96
(B)	2.032	1.848	1.87–1.90
(C)	2.130	1.830	1.87–1.90

(7) Drying

Enamels were air-dried, dried in a hot ventilated drier, and in a hot nonventilated drier, the air of which was well-saturated with moisture.

(8) Base Coat

Acid-resisting enamels were applied as a dust coating over wet, dry, and fired nonacid-resisting enamel bases. The weight of the dust and base coats was varied in amounts of 4 grams, maintaining a total weight of 65 grams. The weight of the base coat varied from 61 to 49 grams per square foot and the dust coat from 4 to 16 grams. This procedure was used in all dust-coat applications. Enamels were also applied directly over the ground coat to a total weight of 65 grams as well as over a single ($32\frac{1}{2}$ grams per square foot) coat of nonacid-resisting enamel in $32\frac{1}{2}$ gram per square foot applications. The weight of the total coat in all cases was 65 grams per square foot, except in the investigation of the effect of increased base-coat weights, where the base coat was applied at 40, 55, 70, 85, and 100 grams per square foot and the acid-resisting enamel at 16 grams.

An investigation was also made of the effect of different base-coat enamels under a dust coat of 15 grams per square foot applied over the wet second coat.

VI. Condensed Outline of Procedure

Because of the involved nature of the investigation, it is believed that the following condensed outline of procedure may prove helpful:

(1) Effect of Metal Gage
(*a*) Metal gage: 12, 14, 16, 18, 20, 22.
(*b*) Acid-resisting enamels: (A), (B), and (C).
(*c*) Application: (1) 65 g./sq. ft. over ground coat; (2) $32\frac{1}{2}$ g./sq. ft. over $32\frac{1}{2}$ g./sq. ft. (fired) base enamel (D); (3) 16 g./sq. ft. over 40, 55, 70, 85, and 100 g./sq. ft. (fired); (4) dust coats: 4, 8, 12, and 16 g. over wet second coat enamel (D) (total application 65 g./sq. ft.).
(*d*) Ventilated gas-fired drier, 190°F.
(*e*) Firing treatment: fired at 1525°F at base-rate time.*

(2) Effect of Firing Temperature
(*a*) Metal gage: 12, 14, 16, 18, 20, and 22.
(*b*) Acid-resisting enamels: (A), (B), and (C).
(*c*) Application: (1) $32\frac{1}{2}$ g./sq. ft. acid-resisting enamels over $32\frac{1}{2}$ g./sq. ft. fired base enamel (D); (2) dust coats 4, 8, 12, and 16 g./sq. ft. acid-resisting enamels over wet second coat enamel (D) (total weight 65 g./sq. ft.).
(*d*) Drying: gas-fired drier at 190°F.
(*e*) Firing treatment: base firing time* at 1475°, 1500°, 1525°, 1550°, and 1575°F for application method (2*c*) and 1475°, 1525°, and 1575°F for application method (1*c*).

(3) Effect of Firing Time
(*a*) Metal gage: 12, 14, 16, 18, 20, and 22.
(*b*) Acid-resisting enamels: (A), (B), and (C).
(*c*) Application method: same as in (2).
(*d*) Drying: gas-fired drier at 190°F.
(*e*) Firing treatment: fired at 1525°F in accordance with time schedule shown in Table I.

(4) Drying
(*a*) Metal gage: 18 and 20.
(*b*) Acid-resisting enamels: (A), (B), and (C).
(*c*) Application: (1) 65 g./sq. ft. over ground coat; (2)

* See Table I.

$32^1/_2$ g./sq. ft. over $32^1/_2$ g./sq. ft. fired base enamel (D); (3) 16 g./sq. ft. over 49 g./sq. ft. (second coat wet) base enamel (D).

(*d*) Dried: (1) air-dried at 70°F; (2) hot ventilated drier 190°F; (3) hot nonventilated drier above 212°F.

(*e*) Firing treatment: 1525°F at base time.†

(5) Application

(*a*) Metal gage: 12, 14, 16, 18, 20, and 22, except as noted.

(*b*) Acid-resisting enamels: (A), (B), and (C), except as noted.

(*c*) Application: (1) 65 g./sq. ft. over ground coat; (2) $32^1/_2$ g./sq. ft. over $32^1/_2$ g./sq. ft. (fired) enamel (D); (3) dust coats: acid-resisting enamels over wet second coat enamel as follows:

Weight acid-resisting (g./sq. ft.)	Weight base enamel (D) (g./sq. ft.)
4	61
8	57
12	53
16	49

(4) dust coat: 15 g./sq. ft. acid-resisting enamels (A) and (B) over 50 g./sq. ft. base enamels (D), (E), (F), (G), and (H), on 20-gage metal.

(*d*) Drying: gas-fired drier at 190°F.

(*e*) Firing treatment: 1525°F at base rate.†

(6) Specific Gravity

(*a*) Metal gage: 20.

(*b*) Acid-resisting enamels: (A), (B), and (C).

(*c*) Application: $32^1/_2$ g./sq. ft. acid-resisting enamel over $32^1/_2$ g./sq. ft. base enamel (D).

(*d*) Specific gravity: See Table II.

(*e*) Drying: gas-fired drier at 190°F.

(*f*) Firing treatment: 1525°F for two minutes.

(7) Reflectance Comparison

(*a*) Metal gage: 12, 14, 16, 18, 20, and 22.

(*b*) Enamels: acid-resisting enamels (A), (B), and (C); base enamel (D).

(*c*) Application: (1) 4, 8, 12, and 16 g./sq. ft. acid-resisting enamel over wet second coat base enamel (D); (total application, 65 g./sq. ft.); (2) base enamel at 49, 53, 57, 61, and 65 g./sq. ft.

(*d*) Drying: gas-fired drier at 190°F.

(*e*) Firing treatment: 1525°F at base time rate.†

VII. Testing

Enamels were tested for acid resistance, surface characteristics, scratch hardness, and, in some cases, reflectance.

(1) Acid Treatment

The cold-type acid-resistance test, as recommended in the tentative test method of the Porcelain Enamel Institute, was followed. This consisted of immersing a portion of each specimen in a fresh (less than 24 hours old) solution of 10% citric acid for fifteen minutes. By immersing from 1 to 2 inches of the 4- by 6-inch test plates, it was possible to compare readily the treated and untreated area of the plate. After immersion in acid, the test plates were washed with soap and water, dried, and classified.

(2) Classification of Acid Resistance

In the classification of acid resistance, an attempt was made to follow as closely as possible the methods being worked out by the Porcelain Enamel Institute Committee,[1] so that the results might be comparable to the results of future investigations. This was somewhat difficult, because the work of the Committee, especially as to classification, was not entirely complete, and a somewhat more expanded scale of classification than the Committee's tentative commercial classification of acid resistance was used. Fortunately, the classification plan worked out for the present investigation and that of the Committee, as outlined in their report[1] of March 6, 1937, may be readily coördinated.

The specimens were first classified for visual attack as follows: (1) no visible attack; (2) and (3) extremely slight visible attack, no loss in gloss; (4) visible attack, slight loss in gloss; (5) and (6) pronounced attack but still showed highlight; and (7) no highlight.

This follows quite closely the blurring and disappearing highlight test reported by the Committee.

Following visual inspection, the specimens were marked on the tested and untested areas with a No. 1 pencil, and an attempt was made to erase the marks first with a clean dry cloth and then with a wet cloth. A comparison was made of the ease of erasure, and a further classification was given.

Visual classification	Pencil mark erasures	Final classification
1	With dry cloth	1
1	" damp "	3
2	" dry "	2
2 and 3	" damp "	3
4 and 5	" " "	4 and 5
1, 2, 4, and 5	Does not erase	6
7	" " "	7

A comparison of this classification with that of the Institute Committee is given in Table III.

† See Fig. 1.

TABLE III
CLASSIFICATION OF ACID RESISTANCE

Classification No.	P.E.I. tentative classification	Classification No.	P.E.I. tentative classification
1	A	5	B–sub-B
2	B	6	Sub-B–C
3	B	7	C–D
4	B		

(3) Surface Characteristics

Shorelines, tearing, pitting, chipping, loss of gloss, and general surface character were observed.

(4) Scratch Hardness

For lack of better method, the Moh scale of hardness was followed.

(5) Reflectance

Diffuse reflectance was measured on a series of acid-resisting enamels applied over a superopaque base enamel, whereon the total enamel weight was maintained at 65 grams per square foot. The amount of acid-resisting enamel in the final coating was increased in increments of 4 grams from 0 to 16 grams per square foot, while the opaque enamel base coating was reduced in like amount. The results were compared with a series of base-coat enamels, applied in weights ranging from 49 to 65 grams in increments of 4 grams. Reflectance was also determined in various other portions of the investigation as deemed necessary. Reflectance was measured on the Hunter photoelectric reflectometer.

VIII. Results

(1) Metal Gage

Tables IV, V, VI, and VII show the effect metal gage has on acid resistance, both with and without the variable factors of firing-cycle changes and variations in application weight. The surface defects are also noted on the tables. Acid-resisting and base-coat weights are $32^1/_2$ grams unless otherwise noted.

Metal gage alone had little or no effect upon the acid resistance of the enamels or upon the surface characteristics of enamels (A) and (C). Enamel (B) showed a tendency to chip on the 12- and 14-gage iron. The reflectance of the acid-resisting enamels tended to decrease somewhat with heavier metal gages, although not as much as base coat.

(2) Firing Treatment

As to acid resistance, firing time, in conjunction with the various metal gages, appeared to cause more variation in acid resistance than firing temperature with enamels (A) and (B). Enamel (A) increased in acid resistance with increased fire, be it by time or by temperature. Enamel (B) gained acid resistance with increased firing temperature, but with increased firing time showed a tendency to gain acid resistance and then lose it with the longer fire. Enamel (A) showed no surface defects with varying time and temperature on the various gages of metal. Enamel (B) showed more defects with time than temperature in that it showed loss of gloss and rough surface. Enamel (C), when underfired by time, showed a different behavior from enamels (A) and (B). With variation in time and metal gage, there was little change except that on 20- and 22-gage metal this enamel showed a tendency to gain acid resistance and then lose it again as the firing time was increased. With temperature, the enamel showed a noticeable improvement with increased firing temperature, especially on 18-, 20-, and 22-gage metal, much more than enamels (A) and (B).

A comparison of Tables V and VI with Table VIII indicated that the dust-coat applications were more sensitive to time and temperature changes than the heavier coats.

These results would indicate that a great deal of care is necessary in working out the proper firing cycle for each type of acid-resisting enamel, especially where the heavier gages of iron are concerned. When the enamels were applied as a dust coat, they appeared to be more sensitive to firing treatment than when applied as a second coat.

Surface defects, in the case of enamel (B), appeared to be somewhat accentuated by the heavier gages of metal.

Reflectance decreased slightly with the higher firing temperatures.

(3) Specific Gravity

Variations in specific gravity did not affect acid resistance. It did, however, affect the surface characteristics of the enamels, giving rise to shorelines with low specific gravities and rough surface with high specific gravities. Especially was this true with enamels (B) and (C).

(4) Drying

As reported by Andrews,[2] drying methods did not affect acid resistance, but they did affect surface characteristics, particularly with dust-coat enamels. Enamel (B) showed a tendency to

shoreline when dried in a hot drier, regardless of its moisture content, but not when air-dried.

(5) Application

The effect of the application method on acid resistance is shown in Table IX.

Enamels (A) and (B) applied over fired base coats gave better acid resistance than over wet or dry base coats. Enamel (C) gave the best results over a wet base coat. Enamels (A) and (B) showed better results with application over wet base coats than over dry base coats. When enamels (A) and (B) were applied over a fired base coat, very light dusting (4 to 8 grams per square foot) gave satisfactory protection. Over wet base coats, at least 8 grams were required, while over dry base coats, 16 grams did not give satisfactory acid resistance. From 8 to 12 grams of enamel (C) over a wet base coat gave better results than heavier coatings over fired enamels. Enamel (C) showed much less decline in acid resistance with low-weight applications than either (A) or (B).

The weight of the base coatings did not affect acid resistance in any case.

The physical properties of the base enamel showed a marked influence upon the surface characteristics of enamels (B) and (C), but not so much on enamel (A). Thin coatings of enamels (A) and (B) showed a more marked tendency toward surface defects than heavier coatings.

Use of enamels (B) and (C) over certain base enamels gave rise to hairlines, shorelines, pinholes, orange peel, fuzzy surface, loss of gloss, and "alligator skin." Enamel (C) was best applied in thin coatings over a wet base coat, while enamel (B) was best applied in heavier coatings over a fired base coat. Enamel (A) did not show a tendency toward defects with any method of application. Very thin coatings showed a slight tendency to reduce scratch resistance, but at weights of 8 grams or more this effect was not noted.

(6) Opacity

Figure 1 shows the effect of dust coatings of the three acid-resistant enamels upon the final reflectance of the base coat, where the total application weight was held constant. Base enamel (D) has a reflectance of 77% at 65 grams per square foot. Curve (*D*) shows the decreased reflectance through a decrease in application weight from 65 to 49 grams per square foot. Curve *A* shows reflectance loss due to enamel (A), about 2% at 16 grams over 49 grams of curve *D*. Curve *B* shows a similar curve for enamel (B) with a loss of $2^1/_2$%. Curve *C* shows the clear acid-resisting

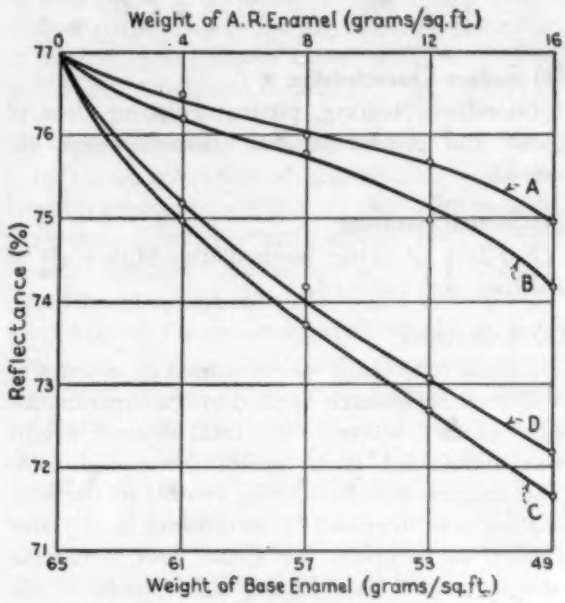

FIG. 1.—Percentage reflectance *vs.* application weights of acid-resisting enamels.

enamel (C) to have but little effect on the reflectance of base enamel (D), regardless of application weights.

(7) Hardness

The Moh method is admittedly not sufficiently sensitive and too much dependent upon the human factor to give closely comparable results.

The tests, however, did not show a total variation of more than one unit throughout, the hardness running from 5 to 6 units on the Moh scale. This may be taken to indicate that once the acid-resisting enamel is fused down well, subsequent treatment does not appear to affect the hardness.

IX. Data

TABLE IV

EFFECT OF METAL GAGE ON ACID RESISTANCE

(Temperature 1525°F; base rate time; base coat (D))

Metal gage	Acid resistance of enamel (A)	(B)	(C)
12	2	1	5
14	1	1	5
16	1	2	5
18	1	1	5
20	1	1	5
22	1	1	4

TABLE V

EFFECT OF METAL GAGE AND FIRING TEMPERATURE ON ACID RESISTANCE

(Base rate firing time; base coat (D))

Temp. °F	Acid-resistance rating of enamel (A) on metal gage of 12	14	16	18	20	22
1475	3	1	2	1	1	1
1500	2	1	1	1	1	1
1525	2	1	1	1	1	1
1550	2	1	1	1	1	1
1575	2	1	1	1	1	1

Temp. °F	Acid resistance of enamel (B) on metal gage of 12	14	16	18	20	22
1475	4*	2*	3	1†	2	2
1500	1*	1	2	1†	2	1
1525	1*	1*	2	1	1	1
1550	1*	1	1	1	1	1
1575	1*	1	1	1	1	1

* Chipping.
† Rough surface.

Temp. °F	Acid resistance of enamel (C) on metal gage of 12	14	16	18	20	22
1475	5	5	5	5	5	3
1500	5	5	5	5	4	3
1525	5	5	5	5	5	3
1550	5	5	5	3	2	1
1575	5	5	5	4	3	3

TABLE VI

EFFECT OF METAL GAGE AND FIRING TIME ON ACID RESISTANCE

(Firing temperature 1525°F, base coat (D))

Time* (long to short)	Acid resistance of enamel (A) on the metal gage of 12	14	16	18	20	22
1	1	1	1	1	1	1
2	1	1	1	1	1	1
3	2	1	1	1	1	1
4	2	2	1	1	1	1
5	2	2	1	1	1	1

* See Table I for Firing Time Schedules.

Time	Acid resistance of enamel (B) on metal gage of 12	14	16	18	20	22
1	2*	1	3	1	1	1
2	1*	1*	2	2	1	1
3	1*	1*	2	1	1	1
4	1*	1*	1‡	2	1†	1‡
5	1*	1*	1‡	3	1	1‡

* Chipping.
† Rough surface.
‡ Dull.

Time	Acid resistance of enamel (C) on metal gage of 12	14	16	18	20	22
1	5	5	5	5	5	4
2	5	5	5	5	5	4
3	5	5	5	5	5	4
4	5	5	5	5	4	3
5	5	5	5	5	5	3

TABLE VII

EFFECT OF METAL GAGE AND APPLICATION WEIGHT ON ACID RESISTANCE

(Acid-resisting enamels over wet second coat (D))

Weight (acid resisting)	Weight (base)	Acid resistance of enamel (A) on metal gage of 12	14	16	18	20	22
16	49	3	1	2	1	1	1
12	53	4	1	2	1	1	1
8	57	4	1	3	2	1	2
4	61	4	3	3	3	6	6

Weight (acid resisting)	Weight (base)	Acid resistance of enamel (B) on metal gage of 12	14	16	18	20	22
16	49	1	2	2	1	1	1
12	53	1	2	2	1	1	1
8	57	3	3	3	1	1	3
4	61	6	3	3*	2	6	6‡

All specimens of enamel (B) in this test showed a tendency to shoreline.
* Mat.
‡ Dull.

Weight (acid resisting)	Weight (base)	Acid resistance of enamel (C) on metal gage of 12	14	16	18	20	22
16	49	5	5	5	4	4	4
12	53	5	5	5	5	4	4
8	57	6	5	5	5	5	5
4	61	7	5	5	5	5	5

TABLE VIII

EFFECT OF TIME, TEMPERATURE, APPLICATION WEIGHT AND METAL GAGE ON ACID RESISTANCE

		Enamel (A) 18-gage metal				20-gage metal			
Weight (acid-resisting)		16	12	8	4	16	12	8	4
Weight (base)		49	53	57	61	49	53	57	61
Time*	Temp. °F	Temperature							
3	1575	1	1	4	6	1	1	1	6
3	1525	1	1	2	3	1	1	1	6
3	1475	1	1	1	6	1	1	1	6
		Time							
1	1525	1	1	5	6	1	1	3	6
3	1525	1	1	2	3	1	1	1	6
5	1525	3	3	6	6	1	1	1	6

* See Table I.

		Enamel (B)							
		Temperature							
3	1575	1	1	3	6	1	1	1	6
3	1525	1	1	1	2	1	1	1	6
3	1475	1	1	2	6	1	1	1	6
		Time							
1	1525	1	1	1	6	1	1	1	3
3	1525	1	1	1	2	1	4	1	6
5	1525	1	1	6	6	1	3	6	6
		Enamel (C)							
		Temperature							
3	1575	5	5	5	5	5	5	5	5
3	1525	4	5	5	5	4	4	5	5
3	1475	5	5	5	5	5	5	5	5
		Time							
1	1525	5	5	5	5	5	5	5	5
3	1525	4	5	5	5	4	4	5	5
5	1525	6	6	6	6	5	5	6	6

TABLE IX

EFFECT OF APPLICATION METHOD ON ACID RESISTANCE

(A) 18-gage metal

Weight (acid-resisting)	Weight (base)	Enamel (A) over base			Enamel (B) over base			Enamel (C) over base		
		Wet	Dry	Fired	Wet	Dry	Fired	Wet	Dry	Fired
65	0			1			1			5
32½	32½			1			1			5
16	49	1	2	1	1	2	1	4	5	5
12	53	1	2	1	1	2	1	5	5	5
8	57	2	2	2	1	2	1	5	5	5
4	61	3	4	2	2	4	1	5	5	5

(B) 20-gage metal

65	0			1			1			3
32½	32½			1			1			5
16	49	1	3	1	1	3	1	4	5	5
12	53	1	3	1	1	3	1	4	5	5
8	57	1	6	1	1	6	1	5	5	5
4	61	6	6	1	6	6	1	5	6	5

TABLE X

EFFECT OF METAL GAGE ON REFLECTANCE OF VARIOUS APPLICATION WEIGHTS OF BASE ENAMEL (D)

Application weight	Reflectance (%) enamel (D) on metal gage of					
	12	14	16	18	20	22
65	76.1	76.4	77.0	77.0	77.1	77.1
61	74.8	75.0	75.8	76.0	75.8	76.0
57	73.5	73.8	75.0	75.0	75.3	75.3
53	72.0	72.3	73.8	73.8	73.9	73.9
49	71.0	71.0	72.3	72.3	72.3	72.3

X. Conclusions

(1) The behavior of acid-resisting enamels, both as to physical behavior and acid resistance, is dependent largely upon enamel composition. Variable factors will affect various types of enamels differently. Acid-resisting enamels should therefore be considered as to type and character rather than as a general class.

(2) Acid-resisting enamels applied as thin coatings (dust coats) appear to be more readily affected by the several variable factors than the same enamels in heavier applications.

(3) Metal gage does not affect acid resistance, if the firing cycle is properly changed, but may affect the physical properties of some enamels. There is an indication that gage variations may require firing-cycle alterations not in proportion to the change in metal weight.

(4) Acid resistance is affected on all gages of metal by time and temperature of firing, but the magnitude of the effect depends upon the type of acid-resisting enamel. Firing time and temperature also affects the physical characteristics of the enamels.

(5) The specific gravity of acid-resisting enamels, when applied, does not affect acid resistance, but does affect surface defects.

(6) Drying methods do not affect acid resistance, but they do affect surface defects.

(7) The effect of weight of coating upon acid resistance depends upon the type of enamel. Class (A) enamels show better acid resistance with heavy coatings, while class (B) to (C) enamels give equal resistance at all weights.

(8) Dust-coat applications are best over fired base coatings.

(9) With class (A) enamels, the safe application weight is between 8 and 12 grams per square foot over wet second-coat nonacid-resisting enamel.

(10) Proper fitting of base enamel to acid-resisting enamels is important from the standpoint of elimination of surface defects, but does not affect acid resistance. This is especially true when the acid-resisting enamel is applied as a dust coat over a wet second coat of nonacid-resisting enamel.

(11) Thickness of base coatings and gage of metal over which various thicknesses of base coating are applied have no effect on acid resistance.

(12) Scratch hardness, as shown by the Moh method, is not greatly affected by the various variable factors.

(13) Combinations of base and class (A) acid-resisting enamels lose opacity more rapidly when the acid-resisting enamels are applied in weights greater than 12 grams per square foot than when applied at lighter weights.

(14) Acid-resisting enamels and acid-resisting combinations do not appear to lose opacity from time and temperature variations and metal gage as rapidly as the nonacid-resisting enamel.

PORCELAIN ENAMEL AND MANUFACTURING COMPANY
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CHARACTERISTICS OF IRON AND STEEL FOR PORCELAIN ENAMELING*

F. R. Porter and J. H. Nead

Abstract

The chemical and physical requirements of porcelain enameling sheets are presented. It is explained why the most satisfactory base metal for enameling purposes is one low in carbon, manganese, sulfur, phosphorus, and silicon. Thermal expansion curves and pertinent photomicrographs are shown.

I. Introduction

The porcelain enameling of sheet metal is a branch of industry which has grown tremendously in recent years and which at present shows no let-up in this remarkable expansion. This increase in the use of porcelain enamel is due mainly (1) to an increasing realization by the consuming public of its superior characteristics, (2) to improvements in quality of the finish owing to scientific developments in the raw materials and in processing, and (3) to a decrease in the cost of producing this finish.

The main requirements of a satisfactory sheet for good enameling properties are (1) uniformity, chemically and physically; (2) soundness, freedom from laminations, blisters, etc.; (3) workability, drawing qualities; (4) quick and clean pickling; (5) no warping at high temperatures; and (6) good welding qualities.

II. Materials Used and Chemical Composition

Ferrous metal sheets used principally for porcelain enameling fall into two classes as to the analysis of the base metal, namely, low carbon or mild open-hearth steel and open-hearth iron.

The use of mild steel is confined almost entirely to kitchenware and to other parts to which only a ground-coat finish is applied.

Enameling iron is the iron universally used by the enameling industry for stove, refrigator, washing machine, sign, and other parts of large-unit construction, where freedom from warpage and finish defects are of paramount importance.

Typical analyses for these two types of materials are as follows:

	Mild steel (%)	Enameling iron (%)
Carbon	0.10	0.03
Manganese	.35	.05
Phosphorus	.015	.010
Sulfur	.025	.025
Silicon	.005	Trace

It will be noted from these analyses that the most important difference is in the amount of carbon and manganese present. The analyses are similar in other respects.

(1) Carbon

Most sheet-metal parts for porcelain enameling have to be stamped or formed or drawn at some stage in their fabrication, and sufficient ductility to withstand such operation is, therefore, a requisite. Ductility in ferrous sheets is obtained by keeping the carbon content low, 0.10% or lower.

It is important also to keep the carbon content at a low value to decrease the possibility of the occurrence of pearlite or carbide areas at the surface of the sheet. Such pearlitic areas might tend to give trouble in the form of gas evolved during the fusion of the enamel, the gas being the result of a reaction of the carbon in the pearlite and the oxides formed on the sheet during fusion according to the following reaction:

$$FeO + Fe_3C = CO + 4Fe.$$

The escape of this gas, carbon monoxide, through the enamel tends to result in a defective enamel finish.

The effect of pearlite areas on an enamel finish is shown in Figs. 1, 2, and 3. Figure 1 shows a copperhead and blistered ground coat resulting from the fusing of a commercial ground coat on enameling iron containing pearlite areas at the surface. The copperhead apparently has resulted from a local over-oxidation due in large part to abnormal gas evolution from the metal surface.

Figure 2 is a photomicrograph of a cross-section of an area similar to that shown in Fig. 1. The section has been etched in concentrated hydrochloric acid to develop the oxide-rich area in the ground coat and then in 3% nitric acid to develop the grain and pearlite areas. The pearlite areas at the surface are clearly shown and are the result of surface carburization, inasmuch as the interior area of the metal is free from carbon. Large bub-

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 23, 1937 (Enamel Division).

bles can be seen in contact with the metal surface as well as a comparatively thick layer of enamel rich in iron oxide.

FIG. 1.—"Bird's-eye" view of copperhead and badly blistered ground-coat enamel over pearlite area; magnification 25×.

Figure 3 is similar to Fig. 2 but of a different area. No large bubbles are visible because they have grown to a critical size, have broken, and have left the iron-rich areas which are known as copperheads. This example is an exaggerated case, but it shows how carbon in the sheet surface

FIG. 2.—Cross-section of area shown in Fig. 1, showing pearlite, bubbles, and ground-coat layer rich in iron oxide; magnification 100×.

will cause boiling in the enamel, copper heads, or both. It also emphasizes the desirability of keeping the carbon content at a minimum in sheet metal for enameling purposes.

(2) Manganese

The typical analyses given cite manganese values of 0.35% for mild steel and 0.05% for enameling iron.

A manganese content of 0.35% is desirable in a mild steel because it is beneficial in improving hot- and cold-working properties at the mill and results in a good drawing steel. Higher manganese contents may be detrimental under certain conditions and may also add to the cost of the steel.

In the case of enameling iron, the manganese content is kept low because experience has shown that the best enameling qualities are obtained in enameling iron when the manganese and carbon

FIG. 3.—Similar to Fig. 2 but of different area; magnification 100×.

are as low as possible. In the open-hearth operation, the manganese content is a guide to the carbon content and the melter knows that when the manganese content is down to 0.05% or lower, the carbon content is also down to the desired point. Because of its low manganese content, enameling iron can not be hot-rolled with the same ease as mild steel, and it is necessary that extra precautions and care be taken by the mill in hot-rolling this stock.

That manganese also has a decided influence on the warping or sagging characteristics will be shown more fully later.

(3) Sulfur and Phosphorus

These elements are kept as low as possible, not primarily because of any direct influence they would have upon enameling properties, but because of the well-known objectionable effects they have upon other physical properties of the material. It is particularly important in the case of enameling iron that the sulfur shall be as low as possible so that the red, short, or "critical working" range of

the material shall not have too wide a temperature range. It should be noted here that the "red short range" means the temperatures at which the metal becomes brittle and difficult to work. Phosphorus is objectionable because it makes the material harder, less ductile, and tends to cause banding of carbon, segregation, etc. No difficulty, however, is experienced in the basic open-hearth process of making low-carbon steel or open-hearth iron in driving the phosphorus content down very low, as can be noted from the typical analyses. Under the strongly oxidizing conditions existing in the open-hearth furnace, the phosphorus is readily oxidized and absorbed in the basic slag. Sulfur is more difficult to remove under the oxidizing conditions existing in making low-carbon ma-

FIG. 4.—Cross-section structure of ingots of mild steel.

terial, but by controlling the sulfur content in the fuel to low values and by high lime charges, it is possible to keep the sulfur down to the desired values.

(4) Silicon

Nearly all sheet metal intended for porcelain enameling contains practically no silicon. This is so because silicon is objectionable for two good reasons, first (and most important), it interferes with pickling, preventing the metal from pickling cleanly and uniformly and leaving a thin scum or deposit, presumably of silica, on the surface. If silicon is present, there are pickling difficulties, both at the steel mill and at the enameling plant. Second, an appreciable silicon content is objectionable from a welding standpoint. In autogenous welding, it tends to produce dirty welds

FIG. 5.—Cross-section structure of ingot of mild steel.

which may later cause trouble when the enamel is applied and fired.

Since silicon is objectionable in sheet iron and steel for porcelain enameling, it is fortunate for the steelmaker that it is almost completely eliminated in the basic open-hearth process for making low-carbon steel and open-hearth iron. Under the existing conditions, silicon is oxidized preferentially to the carbon and manganese; therefore, unless silicon is added, the final analysis will be as given in the typical analyses (in Part II). The absence of silicon from enameling metal means that this grade of material is made in the open-hearth department as a live or rimming steel or iron, since additions of ferrosilicon as a deoxidizer can not be made. This suggests a con-

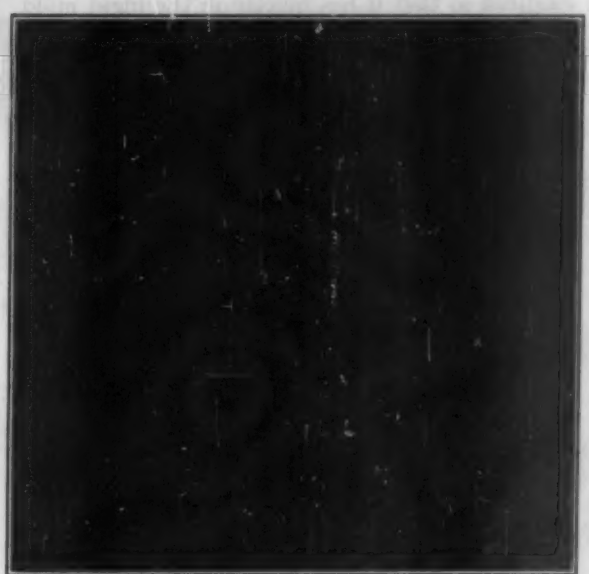

FIG. 6.—Enlargement of Fig. 5, showing one side midway between top and bottom.

sideration of the physical characteristics of the metal.

III. Physical Characteristics

(1) Soundness and Uniformity

Steel or iron as made in the open-hearth department may be divided into two general classes as to its degree of deoxidation and its behavior in the

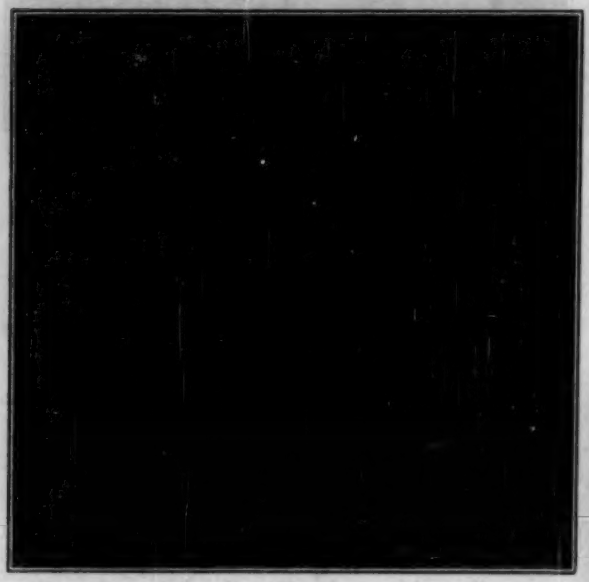

FIG. 7.—Enlargement of Fig. 5, showing bottom corner.

ingot mold; that is, steel may be sufficiently deoxidized so that it lies quietly in the ingot mold, in which case it is said to be "killed," or it may be only partially deoxidized, so that the gas evolu-

FIG. 8.—Cross-section structure of one-quarter ingot of enameling iron.

tion is controlled but not prevented, in which case it is called "rimming" steel or iron.

In the case of "killed" or completely deoxidized steels, the deoxidation is usually done with silicon, but in the case of "rimming" materials, particularly where small amounts of silicon are detrimental, as in enameling stock, the partial deoxidation or control of the gas evolution is usually done with a small aluminum or ferro-titanium addition to the ladle. The gas evolution which produces the "rimming" action in mild steel is due to the reaction between the carbon and the iron oxide dissolved in the metal. This gas evolution during solidification results in the formation of blowholes in the ingot, and it is in control of the blowhole formation by proper deoxidation that much of the skill in making soft steel lies.

Ingots of soft "rimming" steel of about 0.10% carbon will almost always show two distinct sets of blowholes. The first, a set of long blowholes, usually about $^1/_8$ inch in diameter by $1^1/_2$ or 2 inches long, is located perpendicular to the mold wall and close to the surface. These occur near the bottom of the ingot and extend part way up the side,

FIG. 9.—Enlargement of Fig. 8, showing one side midway between top and bottom.

their location being partly dependent upon many variables in pouring practice and in deoxidation. A second set of more rounded blowholes, known as secondary blowholes, usually occurs about four inches in from the ingot surface.

Figure 4 shows two half-ingots of mild steel (ingot size, 24 by 43 by 70 inches), which were split lengthwise to show the ingot structure. This photograph, made for use in connection with a

FIG. 10.—Enlargement of Fig. 8, showing bottom corner.

paper by Washburn and Nead,[1] is shown to impart an idea as to the size of an ingot. Figures 5, 6, and 7, which are sections of a 24- by 43-inch ingot of mild steel show the blowholes referred to.

[1] T. S. Washburn and J. H. Nead, "Structure of Rimmed-steel Ingots." Presented at the A.I.M.M.E. New York Meeting, February, 1937, *Tech. Pub.*, No. 779.

Proper control of deoxidation and of all pouring conditions will sometimes decrease the number and height to which the subcutaneous blowholes extend but will not completely prevent their formation. Enameling iron, because of the fact that carbon is practically absent, does not have nearly so many blowholes as a 0.10% mild steel. The subcutaneous blowholes are never present, and the secondary ones are fewer in number. This is shown by Fig. 8, giving a longitudinal midsection of a 24- by 43-inch enameling iron ingot, and Figs. 9 and 10, which are enlargements of Fig. 8. These sections show that the ingot of enameling iron is much more solid and free from blowholes than the ingot of mild steel. Note the the dish-shaped top of the ingot caused by shrinkage because the volume of the blowholes in the ingot was not sufficient to equal the shrinkage of the liquid metal due to cooling.

Control of blowhole formation so that they shall be few in number and proper heating and rolling operations so that such as do exist shall be as nearly as possible perfectly welded is important in making and rolling sheet metal for porcelain enameling to the end that laminations will not be present to cause blistering in the enameling operation. It is in a large measure because of the

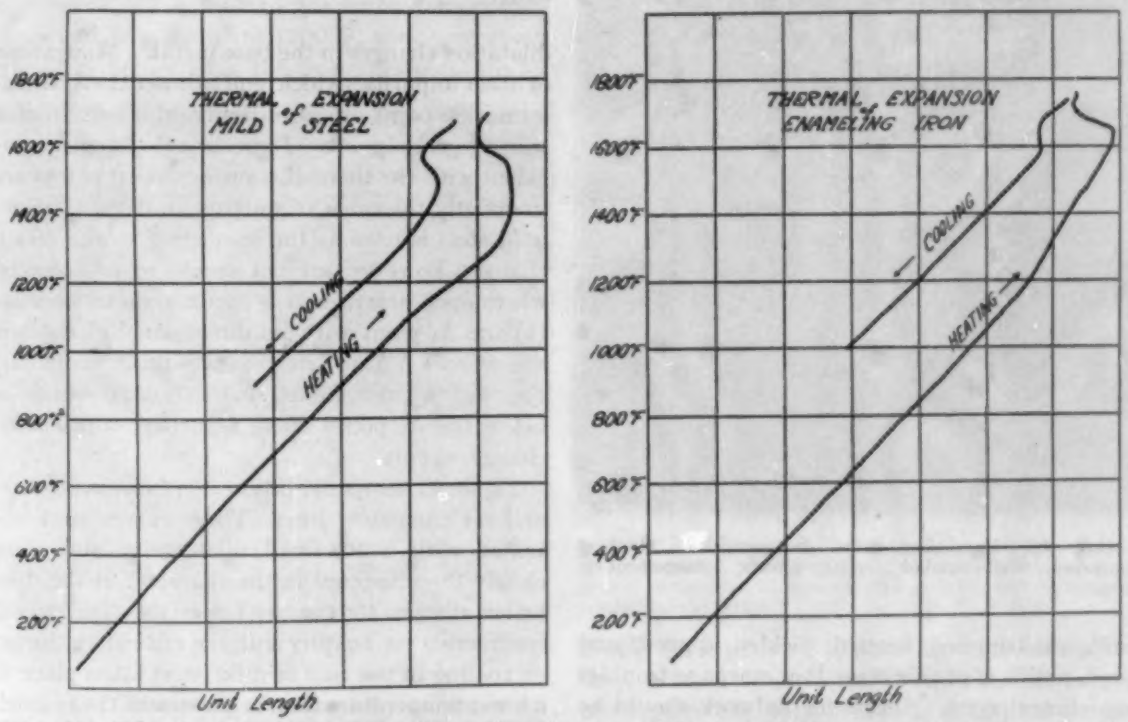

FIG. 11.—Dilatation-temperature curves for mold steel and enameling iron showing temperature ranges covered by critical dimensional changes during heating and cooling.

greater soundness of the ingots that open-hearth iron is accepted as a superior material for porcelain enameling over mild steel.

Another factor of major importance in an enameling stock is consistent uniformity. Chemical and physical uniformity is more important in sheet metal for porcelain enameling than in almost any other application of sheet metal, and in this respect also, because of its greater purity and correspondingly greater chemical and physical uniformity, open-hearth iron surpasses mild steel as an enameling stock.

(2) Warpage

One difficulty with which makers of porcelain-enameled articles, particularly of flatware, such as signs, table tops, panels, etc., have to contend is that of warpage and, because warpage is connected with the fundamental properties of the base metal and stresses placed in the metal, a brief discussion is given. Warpage is usually found in the first firing operation, or the firing of the ground coat, which is usually carried out at about 1580° to 1600°F. For such parts as referred to, sheets in the annealed condition, furnished by the steel

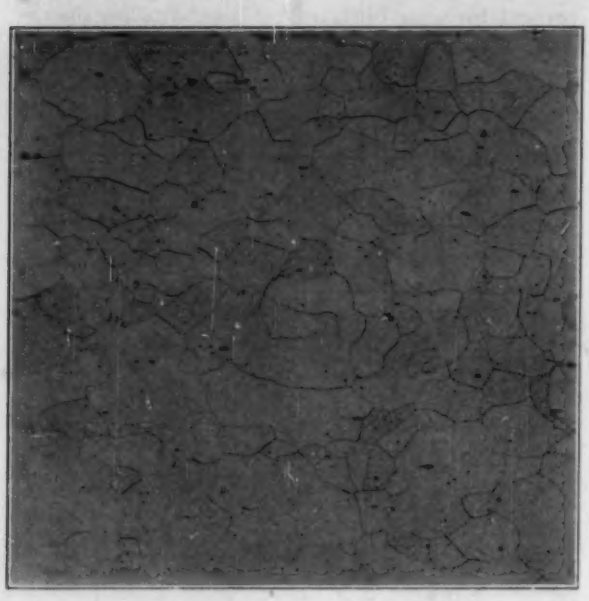

FIG. 12.—Enameling iron, box-annealed, showing equiaxed, well-rounded ferrite grains; magnification 100×.

mill, are trimmed, formed, pickled, dipped, and fired, and it is at this stage that warpage troubles sometimes occur. Sheets for flatwork should be furnished by the maker sufficiently annealed so that rolling strains are relieved and, generally, they are so furnished.

This matter of warpage, however, is another instance in which the carbon content plays an important part, with the result that the lower the carbon the less is the danger from warpage resultant from

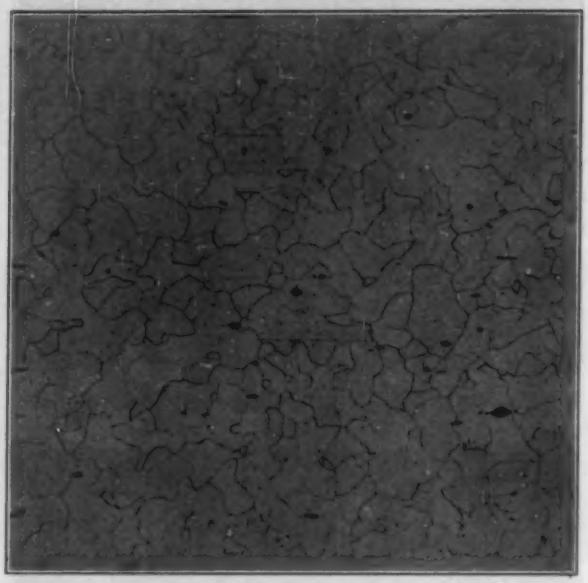

FIG. 13.—Enameling iron, normalized, showing equiaxed, irregular-shaped ferrite grains; magnification 100×.

dilatation changes in the base metal. Manganese or other impurities which tend to lower the A_3 transformation point are also disadvantageous from a warpage standpoint. Dimensional changes coincident with the thermal transformation points are frequently the cause of warpage in flatwork when mild steel is used as the enameling stock. Such changes, however, are not nearly so pronounced where open-hearth iron is the base metal because (1) the A_1 point with its dimensional changes is absent and (2) the firing operation is usually carried out at not more than 1600°F, which is below the A_3 point where a further dimensional change occurs.

Figure 11 shows dilatation curves for mild steel and for enameling iron. These curves were obtained with a Rockwell dilatometer and show clearly the difference in the character of the dilatation changes for the two materials. The critical contraction on heating and the critical expansion on cooling in the case of mild steel takes place at a lower temperature than in the case of the enameling iron and is nearly coincident with the firing

temperature for the ground-coat enamel. The critical change in the expansion curve covers a wide temperature range from about 1300°. to 1570°F in the case of the mild steel; for the

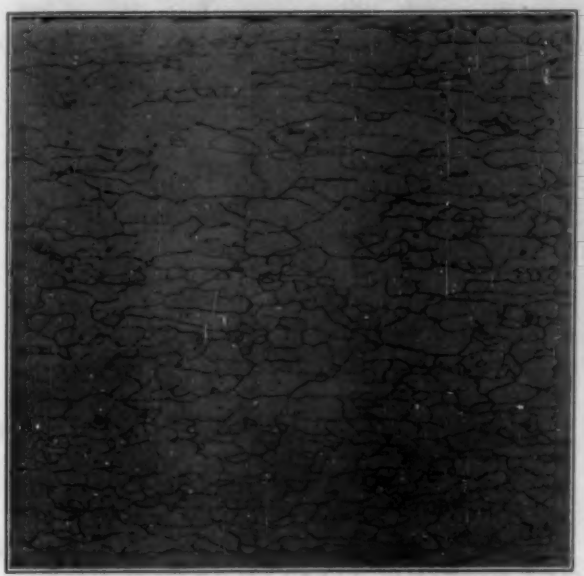

FIG. 14.—Enameling iron, box-annealed, showing elongated but strain-free ferrite grains; magnification 100×.

enameling iron, this critical change in the expansion curve is confined to a narrow temperature range of about 1630° to 1700°F, which, as above stated, is higher than the firing temperature for

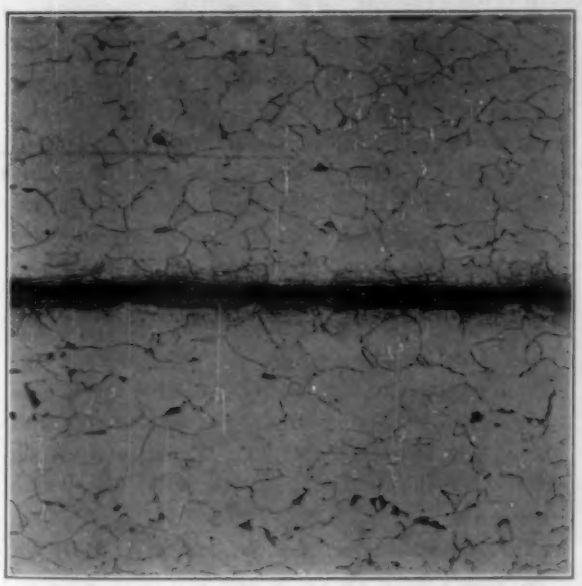

FIG. 15.—Mild steel, box-annealed, showing equiaxed, well-rounded ferrite grains and small pearlite areas; magnification 100×.

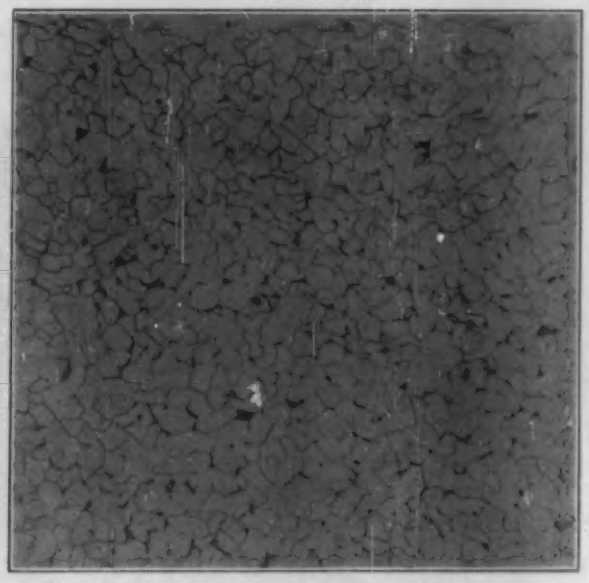

FIG. 16.—Mild steel, normalized, showing small equiaxed ferrite grains and small pearlite areas; magnification 100×.

the ground-coat enamel. This temperature difference, however, is not great, and it is, therefore, important that carbon and manganese, which tend to lower the temperature of the A_3 transformation,

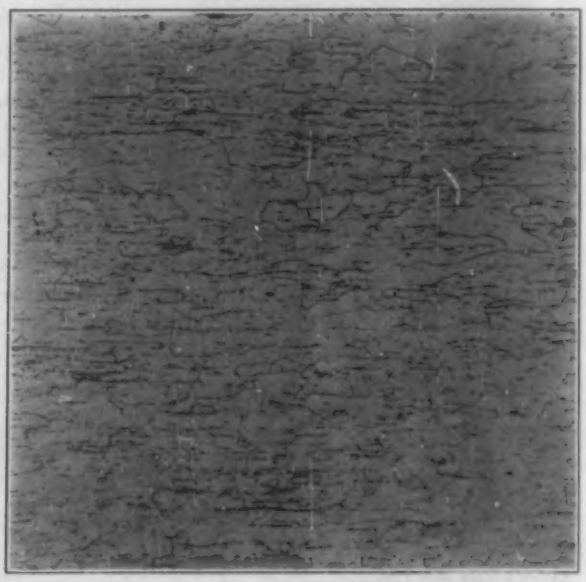

FIG. 17.—Mild steel, box-annealed, showing slightly under-annealed condition, but rolling strains relieved; grains somewhat elongated and pearlite not re-formed; magnification 100×.

should be kept as low as possible. The absence of these critical dimensional changes results in less warpage where open-hearth iron is used as the base metal for porcelain enameling.

The matter of proper annealing to remove rolling strains is, of course, important in preventing warpage. This does not mean, however, that a completely equiaxed grain structure is necessary. Rolling strains can be completely removed from a sheet which, upon microscopic examination, will still show considerable elongation to the grains. Such a structure (Fig. 14) shows an elongated but strain-free grain structure in a box-annealed enameling iron sheet. Other typical structures of box-annealed and normalized enameling iron and mild steel are given as a matter of interest (see Figs. 12 to 17).

The manner in which sheet metal for enameling purposes is annealed, that is, whether box-annealed or open-annealed, will depend upon the customer's requirements and the purposes for which the material is to be used.

IV. Conclusions

In conclusion, it may be stated that the porcelain-enameling industry now uses two basic open-hearth products as base metal for enameling sheets, namely, low-carbon mild steel and open-hearth iron. Because of the supreme importance of very low carbon and silicon contents, as well as low manganese and the other metalloids, and because of the importance of soundness, uniformity, weldability, and freedom from warpage, the industry has adopted the purer material, open-hearth iron, particularly for its better-grade products and for its more exacting requirements.

Acknowledgments

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OPTICAL SPECIFICATION OF VITREOUS ENAMELS*

By Deane B. Judd, W. N. Harrison, and B. J. Sweo

Abstract

In 1931, Kubelka and Munk worked out the relationship between reflectance and thickness of material for thin, homogeneous layers illuminated diffusely. In the equation expressing this relationship, the hypothetical ideal material is defined by two constants, reflectivity and coefficient of scatter. In the present paper are presented data demonstrating how well the reflectance characteristics of vitreous enamels can be specified by these constants.

I. Introduction

Relations between the incident, reflected, and emergent light from a thin, homogeneous layer of absorbing and scattering material have been worked out in various forms.[1] Usually these relations have been developed in theory by considering perfectly diffused light incident on any elementary layer of the material, which is assumed to absorb a portion, reflect diffusely another portion, and transmit diffusely the remainder. Traveling of the diffused light through the thin sheet of material has been considered, but scattering of light to the sides or light lost through the edges of the material has usually been left out of account because of the added complexity. Of the various simplified derivations, the most readily applicable to practical measurement is that of Kubelka and Munk, who carried through the derivation in such a way that the related quantities are those which

* This paper is a condensation of one of broader scope entitled, "Optical Specification of Light-Scattering Materials," *Nat. Bur. Stand. Jour. Research*, **9**, 287 (1937) RP 1026, which concerns also cold-water paints, papers, and dental-silicate cements. A paper entitled, "Specification of Light-Scattering Materials," covering essentially the scope of the present paper, was given at the Thirty-Eighth Annual Meeting, American Ceramic Society, Columbus, Ohio, April 1, 1936 (Enamel Division). Received July 26, 1937.

[1] (*a*) G. G. Stokes, "On the Intensity of Light Reflected from or Transmitted through a Pile of Plates," *Proc. Roy. Soc.* [London], **11**, 545 (1860–62).

(*b*) H. J. Channon, F. F. Renwick, and B. V. Storr, "Behavior of Scattering Media in Fully Diffused Light," *Proc. Roy. Soc.* [London], **A94**, 222 (1918).

(*c*) L. Silberstein, "Transparency of Turbid Media," *Phil. Mag.*, [7], **4**, 1291 (1927).

(*d*) M. Gurevich, "Über eine Rationelle Klassification der Lichtstreuenden Medien," *Physik. Z.*, **31**, 753 (1930).

(*e*) J. W. Ryde and B. S. Cooper, "Scattering of Light by Turbid Media," *Proc. Roy. Soc.* [*London*], **A131**, 451 (1931).

(*f*) P. Kubelka and F. Munk, "Ein Beitrag zur Optik der Farbanstriche," *Z. tech. Physik.*, **12**, 593 (1931).

(*g*) T. Smith, "Hiding Power of Diffusing Media," *Trans. Optical Soc.*, **33**, 150 (1931–1932).

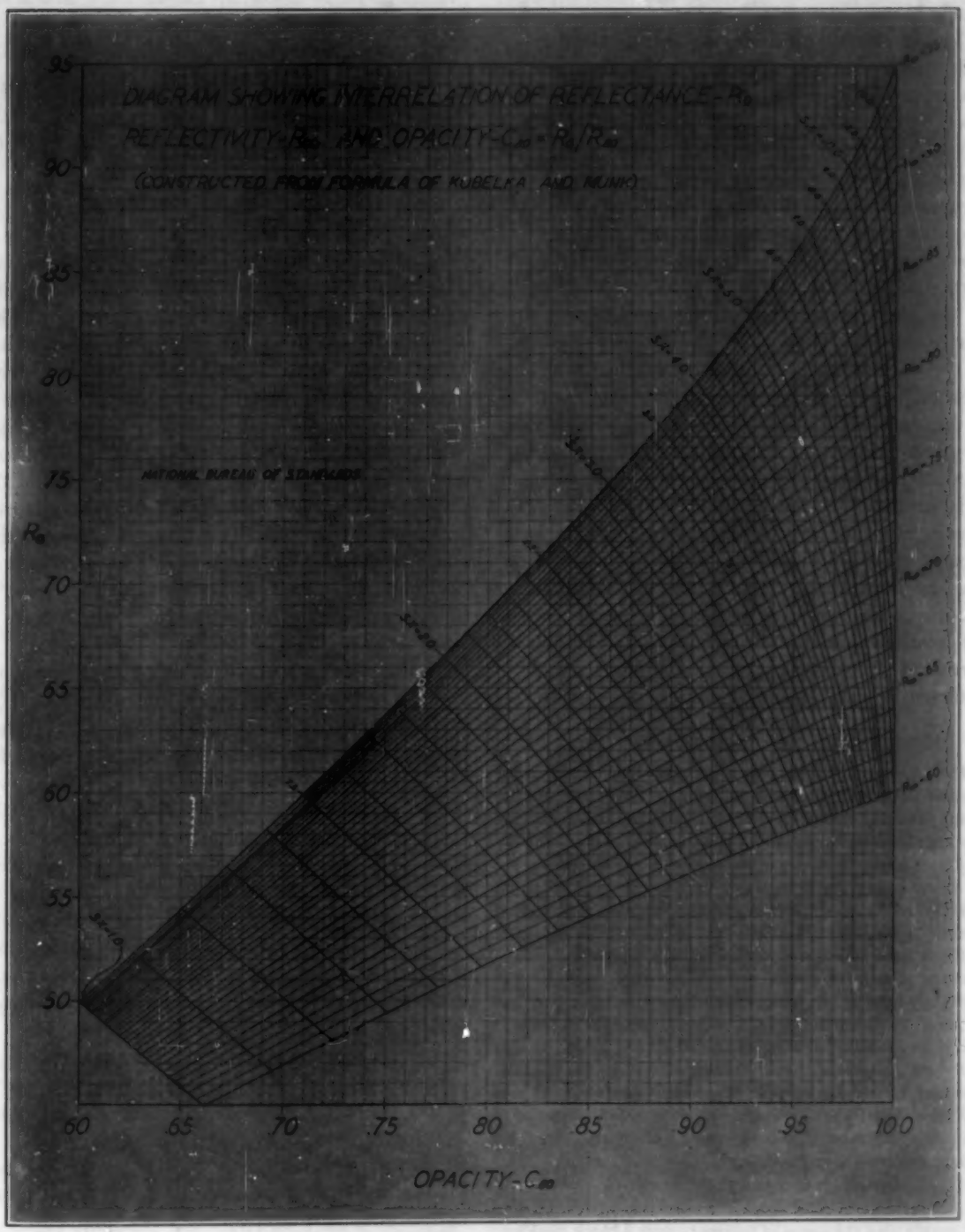

FIG. 1.—Reflectance-opacity chart.

are customarily measured. The equations of this important derivation have been reproduced and the discussion of them is given in English by Steele.[2]

Measurements on materials result in values of reflectance which are related to the thickness of the material in a way somewhat different from that described by the Kubelka-Munk formula (1) because reflectometers fail either to diffuse perfectly the light falling on the specimen or to measure all light diffusely reflected or both; (2) because some light is lost through the edges of specimens; (3) because the amounts of light absorbed and scattered by materials vary according to the wave-length of the light, and (4) because materials differ from the ideal material assumed in the derivation by being inhomogeneous. This inhomogeneity, in the case of vitreous enamels, is due to the fact that there are light-scattering elements suspended in a matrix. The outer surface of this matrix reflects part of the incident light and part of the internally reflected light, returning the latter into the specimen. The purpose of the present paper is to discover how large are the departures of experimental results from theory and to inquire whether a description of the reflectance characteristics of vitreous enamels in terms of the simple Kubelka-Munk formula is sufficiently exact to be of value.

II. Definition of Terms

$R \equiv$ light reflectance of a specimen, or the fraction of incident light reflected from a specimen. (Except for the ideal, perfectly diffusing specimen, reflectance depends on the angular distribution of incident light.)

$R_\infty \equiv$ light reflectivity of the material, or the reflectance of an infinitely thick specimen of the material; that is, practically, one so thick that a further increase in thickness does not change its reflectance.

$R_0 \equiv$ light reflectance of a specimen in contact with a backing of zero reflectance.

$R_R' \equiv$ light reflectance of a specimen in contact with a backing of reflectance, R'.

$C_R' \equiv R_0/R_R'$, called contrast ratio.

$P \equiv C_{0.80}$ for an enamel coating of 6.0 g./dm.^{2}, called covering power in the case of vitreous enamels. (P is a special case of C_R'.)

$X \equiv$ thickness of the specimen (often measured by weight per unit area).

$S \equiv (dR_0/dX)_{X \to 0}$, called coefficient of scatter, the rate of increase of reflectance of a specimen with thickness for nearly zero thickness of specimen over a black backing.

$SX \equiv$ scattering power of a particular specimen consisting of a thickness, X, of material having coefficient of scatter, S.

III. Formulas and Graphical Aids

The Kubelka-Munk formula is

$$R_R' = \frac{\frac{1}{R_\infty}(R' - R_\infty) - R_\infty\left(R' - \frac{1}{R_\infty}\right)e^{SX(1/R_\infty - R_\infty)}}{(R' - R_\infty) - \left(R' - \frac{1}{R_\infty}\right)e^{SX(1/R_\infty - R_\infty)}} \quad (1)$$

From two measurements of reflectance, R_R', of a specimen of known thickness, X, one for each of two backings of different reflectance, R', it is possible to solve for R_∞ and S from equation (1), and so obtain a specification of the material. This can also be done from two measurements of reflectance made with the same backing but with samples of different thickness, X. The form of equation (1) is, however, so little adapted to easy solution for the unknowns that all of the solutions required for reducing the experimental data of the present study have been worked out in advance and expressed graphically on a reflectance-opacity chart by families of curves for different values of SX and R_∞. The ordinate of such a chart is reflectance, R_0, for black backing; the abscissa is contrast ratio, C_R'.

In choosing a specific value of C_R' for such a chart, it is desirable to have as high a value of R' as can conveniently be used as backing for the test coating. $R' = 0.80$ was selected as suitable for vitreous enamels and used in Fig. 1. The curves in this figure having positive slopes represent the increase in reflectance and opacity of specimens made of increasing thicknesses of the same ideal material. The highest reflectance is obtained, of course, for specimens so thick that they are opaque ($C_{0.80} = 1.00$), and this maximum reflectance is the reflectivity, R_∞. The relative thicknesses of the specimens are indicated by the intersections with the curves having negative slopes. Each of the latter curves represents ideal specimens of constant scattering power, SX; each such curve shows the decrease in reflectance, R_0, for black backing and the increase in opacity, $C_{0.80}$, of such specimens as their reflectivities are lowered, for example, as by admixture of a nonscattering, light-absorbing material like black pigment.

Several ways of using Fig. 1 to estimate the constants, R_∞ and S, from data are described in this paper. In one of these methods, $C_{0.80}$ ($= R_0/R_{0.80}$) is determined experimentally, and it often

[2] F. A. Steele, "Optical Characteristics of Paper: I, Mathematical Relationships between Basis Weight, Reflectance, Contrast Ratio, and Other Optical Properties," *Paper Trade Jour.*, 100 [12] 37 (March 21, 1935).

happens that the backing for the test coating which should have a reflectance of 0.80 actually has a somewhat higher or lower reflectance, R'. In such cases, a means of correcting the observed $C_{R'}$ to $C_{0.80}$ is necessary in order to use Fig. 1 with accuracy. For this purpose the following formula was derived:

$$C_{0.80} = \frac{1 - 0.80R_0}{0.20 + \dfrac{0.80(1-R'R_0-C_{R'} + R'C_{R'})}{R'C_{R'}}} \quad (2)$$

The solid curves in Fig. 2 were computed from equation (2) and, by virtue of the near proportionality between correction and deviation of R' from 0.80, they serve the purpose of equation (2)

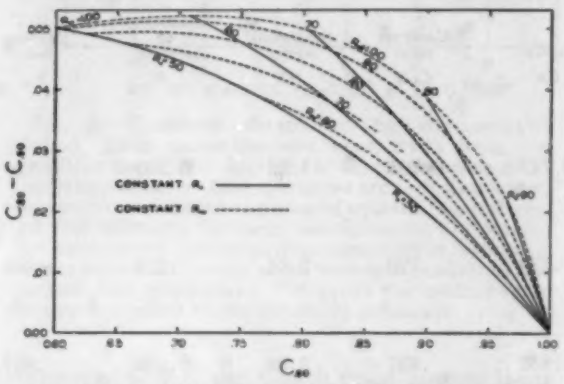

FIG. 2.—The change in contrast ratio produced by a 10% change in reflectance of white backing; to be used when the actual white backing has a reflectance different from 80%. This graph extends the application of Fig. 1.

for most cases arising in practice. The dotted curves (constant R_∞) in this figure were found by reference to Fig. 1 and are often more convenient for obtaining interpolated values than the solid curves (constant R_0).

IV. Selection of Apparatus

Opaque coatings may be classified as (1) those in which the scattering elements are distributed in air as the medium (uncoated papers, cold-water paint films) and (2) those in which the medium is not air (vitreous enamels, oil paints).

The pertinence of this classification lies in the assumption by Kubelka and Munk that the hypothetical material to which their formula strictly applies is homogeneous. For materials whose scattering elements are distributed in a medium different from air, it is not legitimate to allow light reflected from the outer side of the air-medium surface to be added to the light reflected from the body of the material. (Furthermore, since the theory does not take into account any light reflected back into the body of the material from the inner side of the air-medium face, it could not be expected to describe the facts fully, even if light reflected from the outer side of the air-medium face could be eliminated.) If, however, samples of such materials have optically smooth surfaces, light reflected from the outer face can be left out of account by so illuminating and viewing the samples that specularly reflected light does not enter the viewing element of the reflectometer.

In preliminary tests, it soon became evident that the inspection areas covered by most reflectometers (usually 6 square centimeters or less) were not large enough to be representative of specimens 1 decimeter square having thin enamel coatings of low opacity, because such coatings were generally not sufficiently uniform. Because, for practical reasons it is not feasible to reduce the size of enameled specimens drastically below 1 square decimeter, a reflectometer covering a large fraction of this area was desired. An instrument which would give a precise result quickly, the Hunter "photox photoelectric" reflectometer,[3] was designed especially to fulfill this combination of requirements and was used in this work.

V. Experimental Work

(1) Contrast-Ratio Method

The first method of study was to determine the contrast ratio, $C_{0.80}$, and from this value, together with the reflectance, R_0, of coatings of known weight per unit area, X, over black backing, to estimate the constants, reflectivity, R_∞, and coefficient of scatter, S, by means of the chart shown in Fig. 1. This method involved the preparation of test blanks with a black enamel on one half and a white enamel of reflectance 0.80 on the other half.

NOTE: The white and black backings could be used on separate specimens, but this procedure would involve the comparison of pairs of specimens with equal coatings of test enamel.

Figure 3 is representative of the more favorable results obtained by this method. The data corresponding to this figure, which were obtained from highly opaque enamel frit with no opacifier added at the mill, are given in Table I. The constants, R_∞ and S, were computed four times, from four

[3] R. S. Hunter, "Null Method Photoelectric Reflectometer," *Jour. Optical Soc. Amer.*, **26**, 225 (1936); *Bull. Amer. Ceram. Soc.*, **15** [3] 79 (1936); *Better Enameling*, **7**, 12 (1936).

groups of three specimens each, at different average thicknesses of the test coating. The R_0 values of these contrast-ratio specimens are shown in Fig. 3 as circles, squares, crossed circles, and crossed squares, respectively. The solid circles represent independently determined points obtained from coatings over ordinary black-coated blanks, rather than contrast-ratio blanks.

It is seen that the four pairs of independently determined constants agree reasonably well with each other (Table I) and that all of the experimental points fall close to the theoretical line corresponding to the average value of the two constants (Fig. 3).

TABLE I

REFLECTANCE DATA FOR ENAMEL (1), CONTRAST-RATIO METHOD

	Reflectance of backing R'	Weight of enamel (g./dm.²) X	Reflectance of coating over: Black backing R_0	Reflectance of coating over: White backing $R_{R'}$	$R_0/R_{R'}$ $C_{R'}$	Contrast ratio C_{∞}	Scattering power SX	Coefficient of scatter S	Reflectivity R_∞
	0.814	3.99	0.599	0.840					
	.825	4.22	.616	.846					
	.812	4.27	.618	.840					
Av.	.817	4.16	.612	.842	0.727	0.735	1.62	0.389	0.880
	.810	4.88	.650	.842					
	.813	5.41	.664	.849					
	.815	5.66	.678	.850					
Av.	.813	5.32	.664	.847	.784	.790	2.04	.379	.886
	.816	7.31	.726	.858					
	.816	7.27	.732	.859					
	.807	7.41	.739	.859					
Av.	.813	7.33	.732	.859	.852	.857	2.88	.393	.897
	.812	7.43	.726	.856					
	.809	8.22	.749	.859					
	.815	8.41	.758	.860					
Av.	.812	8.02	.744	.858	.867	.872	3.09	.384	.888

Such fairly consistent results were not obtained, however, without close attention to numerous details and even then not in all cases. This fact is probably due in part to sources of error peculiar to this method of test. Known deviations from 0.80 in the reflectance of the white backing were corrected for by means of Fig. 2, but any change in reflectance of the backing which might occur during the firing of the test coating could not be similarly corrected for, because both its direction and extent were unknown. Errors in reflectance measurements may also be accentuated in the ratio of two reflectance measurements, from which the contrast ratio was determined. Furthermore, the assumption that the enamel is applied in equal thicknesses to both ends of the specimen, although this condition was sought, is subject to more or less error, depending on the skill of the operator. Less opaque enamels appeared to be more affected by the sources of error, because, in general, results for them were less satisfactory.

No data in addition to Table I and Fig. 3 are given for the contrast-ratio method, since the data obtained were largely of a preliminary nature and were unsuitable for drawing definite conclusions. Rather than make a more exhaustive study of this method and the perfection of a dependable technique applicable to all classes of white enamel, the following method was investigated which, it was hoped, would be less dependent upon carefully controlled technique and specialized skill for satisfactory reproducibility.

(2) Reflectivity Method

(*a*) *Technique:* In this method the reflectivity was determined by direct measurement of the reflectance of a thick coating. The thickness required may be seen from Fig. 1 to correspond to scattering power, SX, of 16 for reflectivities up to 0.85; even for reflectivity 0.90, the reflectance, R_0, for this scattering power differs from the reflectivity only by 0.005. Preliminary data indicated that suitable scattering powers could be obtained by coatings of 75 g./dm.²

Although reflectances of these heavy coatings can not be used alone to obtain coefficients of scatter, they may be used for this purpose when combined with reflectance data for the thinner

coatings as used commercially for wet-process enamels (4 to 9 g./dm.², dry weight). Ordinarily one specimen was coated at about 4 g./dm.², one at about 4½, and so on by approximately half-gram

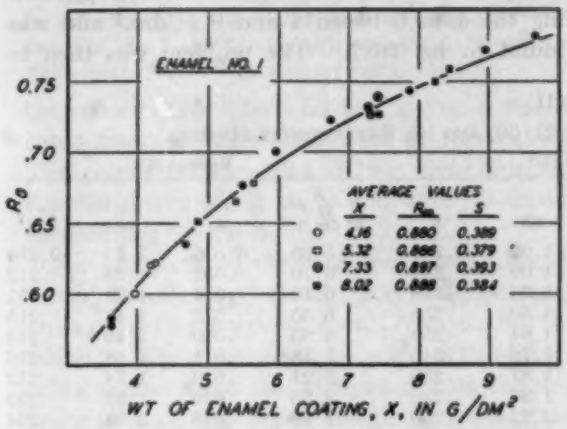

FIG. 3.—Constants determined by contrast-ratio method. Four determinations were made from the respective averages of four sets of three specimens each. The values of R_0 for these specimens are shown as circles, squares, crossed circles, and crossed squares, respectively, and the constants for each determination are shown. The solid circles represent determinations of weight of coating *versus* reflectance which were independent of the contrast-ratio specimens. The curve was plotted from the average values of the respective constants.

increments to 9 g./dm.², each dried coating being weighed by difference to the nearest 0.01 gram. For enamels, however, having very low covering power, P, it was found advisable to use somewhat greater thicknesses.

To keep the firing practice as uniform as possible, the specimens in this range of thickness were fired in a single firing period (for the cover coat). The heavier coats were applied in two (or if necessary, three) sprayings, any spray coat subsequent to the first being kept dry enough by adjustment of the spray gun to prevent its glossing over during spraying. (Without this precaution, the application of two or more spray coats before firing was not uniformly successful.) The specimens coated with 75 g./dm.² of enamel could be prepared in the same fashion, by spraying on numerous coats to be fired at once, but although this process was tried successfully, it was considered to be more practicable to dry out the wet-ground enamel slip and to apply the resulting powder by the dry process.

(*b*) *Results:* Three enamels were tested by the reflectivity method; one enamel of high covering power, P, one low, and one intermediate. All were given equal grinding treatment with 7 parts by weight of clay for each 100 parts of frit, and no opacifier was added at the mill.

The results are shown in Table II and Fig. 4. From the average values of R_∞ and the observed values of R_0 for the respective specimens in the weight-reflectance series, the scattering power, SX, for each such specimen was read from Fig. 1, and the coefficient of scatter, S, was computed in each case by dividing this figure by the weight per unit area, X. The curves represent ideal specimens of material having reflectivities and coefficients of scatter equal to the respective average values for these three enamels; they were plotted from points read from Fig. 1.

If the data were in perfect accord with the theory, the values of S for each enamel, given in Table II, would be constant, and the points indicated by circles in Fig. 4 would fall exactly on the respective curves. The indication is that the theory fits the data within the experimental accuracy. It is of interest that the deviations from the theoretical curves do not exceed 0.013, a difference which ordinarily can not be detected with certainty by direct visual comparison of two specimens of white enamel.

(*c*) *Significance of Results:* The constants given in Table II indicate the character of the differences between the three enamels. Thus, the reflectivity of enamel (3) is slightly lower than that of enamel (2), the difference being only 0.013. Nevertheless, the coefficient of scatter of enamel (3) is sufficiently lower that the reflectance of a

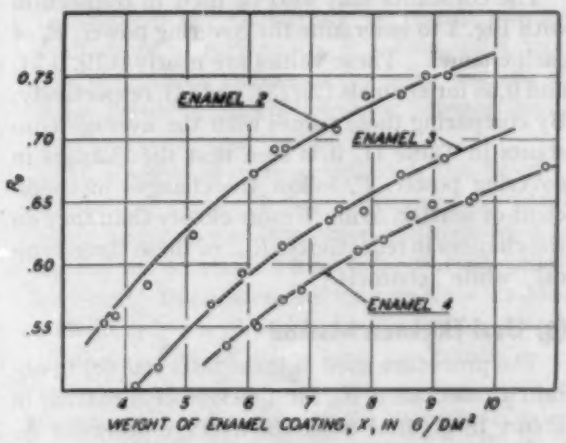

FIG. 4.—Constants determined by direct observation of reflectivity and use of the observed value, R_∞, with plotted values of R_0, to read coefficient of scatter from Fig. 1.

coating of 6 g./dm.² is only 0.59, while that of enamel (2) is 0.67. The differences in reflectance characteristics between enamels (3) and (4) are of a rather different nature; that is, the coefficients of scatter are considerably closer together, but the difference of 0.065 in reflectivity is much larger than that between enamels (2) and (3). The reflectance difference between enamels (3) and (4) for a coating of 6 g./dm.² is only that from 0.59 to 0.55, or 0.04; this difference is about half that between enamels (2) and (3) at the same weight.

The constants may also be used in connection with Fig. 1 to determine the covering power, P, of each enamel. These values are nearly 0.79, 0.71, and 0.68 for enamels (2), (3), and (4), respectively. By comparing these values with the average constants in Table II, it is seen that the changes in covering power, P, follow the changes in coefficient of scatter, S, much more closely than they do the changes in reflectivity, R_∞, of these three typical "white" enamels.

TABLE II

REFLECTANCE DATA FOR ENAMELS (2), (3), AND (4), REFLECTIVITY METHOD

Enamel (2)*				Enamel (3)†				Enamel (4)‡			
X (g./dm.²)	R_0	SX	S	X (g./dm.²)	R_0	SX	S	X (g./dm.²)	R_0	SX	S
3.65	0.553	1.25	0.342	4.16	0.501	1.02	0.245	5.65	0.536	1.21	0.214
3.83	.559	1.28	.334	4.53	.518	1.09	.241	6.10	.552	1.29	.212
4.35	.584	1.43	.329	5.40	.567	1.33	.246	6.12	.551	1.29	.211
5.08	.624	1.69	.333	5.87	.594	1.50	.255	6.55	.572	1.41	.215
6.06	.673	2.12	.350	6.55	.616	1.64	.250	6.85	.580	1.46	.213
6.40	.692	2.32	.362	7.30	.635	1.79	.245	7.78	.611	1.68	.216
6.58	.693	2.34	.356	7.49	.644	1.87	.250	8.21	.619	1.74	.212
7.42	.708	2.52	.340	7.88	.643	1.86	.236	8.65	.639	1.92	.223
7.88	.734	2.89	.367	8.47	.672	2.12	.250	8.99	.648	2.01	.224
8.46	.736	2.92	.345	9.18	.686	2.28	.249	9.60	.650	2.02	.210
8.87	.750	3.16	.356					9.64	.653	2.07	.215
9.22	.751	3.18	.345					10.81	.678	2.35	.217
			Av. 0.348				Av. 0.247				Av. 0.215

* R_∞ = 0.901, 0.897; av. 0.899.
† R_∞ = 0.884, 0.887; av. 0.886.
‡ R_∞ = 0.824, 0.818; av. 0.821.

(3) Dual Thickness Method

The procedure used in these tests was (*a*) to obtain a reflectance, R_0, for a wet-process coating of about 18 g./dm.² from the average observed reflectance of two specimens having that weight of coating and (*b*) in the lower-weight range to determine the reflectance for a coating of one-third the above-stated thickness by interpolation from a set of specimens prepared as previously described. The constants were determined from Fig. 1, as illustrated by the following case, the data for which are shown in Fig. 5. The average coating of the two most heavily coated specimens was 17.85 g./dm.² and the average reflectance was 0.833. The reflectance corresponding to 5.95 g./dm.² (one-third of 17.85 g./dm.²) was read by interpolation on a smooth curve closely representing the data between 4 and 9 g./dm.² and was found to be 0.687. The problem was then to find a constant reflectivity line on Fig. 1 such that the scattering power, SX, at a reflectance of 0.833 is three times the scattering power at a reflectance of 0.687. It was found by inspection that the line for R_∞ = 0.87 approximately meets this condition. The ratio of the scattering powers is 2.94 for R_∞ = 0.87 and 3.15 for R_∞ = 0.86, and, by interpolation, the ratio is equal to 3.0

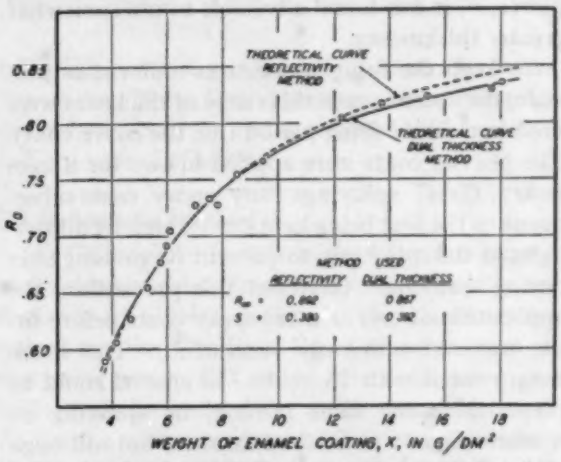

FIG. 5.—Continuous line corresponds to constants determined by the dual thickness method; dotted line to constants determined by the reflectivity method.

when $R_\infty = 0.867$, which is, therefore, the reflectivity sought. The coefficient of scatter, S, was found by dividing out X from either of the two scattering powers, SX, which served to identify the reflectivity. The solid line in Fig. 5 was located from constants determined by this method. The points between 12 and 16 g./dm.^{2} represent supplementary check values and were not used in determining the constants.

NOTE: A set of curves, giving a rapid explicit solution for reflectivity, to replace the trial-and-error solution by means of Fig. 1, could be prepared and should be available if this method were to be used regularly.

For comparison, the reflectivity was also observed directly as previously described from specimens coated by dry process with 75 g./dm.^{2} of this enamel. The observed value was 0.892, which is 0.025 greater than that computed from the wet-process data. The dotted line in Fig. 5 was drawn from this value of R_∞, and the value of S was computed by Fig. 1 from it and the same point on the weight-reflectance curve used before, namely, $X = 5.95$ and $R_0 = 0.687$. The constants obtained by the two methods are given in Fig. 5.

It is seen from Fig. 5 that the curve obtained by either method fits the observed points in the practical range 4 to 9 g./dm.^{2} within experimental accuracy and that above this range some points are closer to one curve and some to the other.

VI. Discussion

It was discovered independently, in 1934, by McIntyre[5] that the variation in reflectance of enamels with thickness of coating could be represented over the practical range of thickness by the following simple empirical formula:

$$R = \frac{X}{mX + b}, \qquad (3)$$

Where m and b = constants of the material.

Comparison of this formula with the Kubelka-Munk theory shows close agreement over the practical range of thickness. Since equation (3), however, departs importantly both from the Kubelka-Munk theory and from experimental results for very thick coatings, the constants of this formula can not be given a physical significance and in this paper attention has been confined to the more fundamental Kubelka-Munk relation.

It is not considered necessary here to give more than a limited amount of data, which serve for illustrative purposes. Data not reported here also substantiate the statement that the difference between reflectivity values obtained by the two processes described in connection with Fig. 5 was reproducible; that is to say, the difference occurred consistently in the same direction and approximately to the same degree when repeat tests were made under the same conditions. It is important to note, however, that four parts of an opacifier were used in the mill batch. The differences which other mill opacifiers may exhibit in this respect were not determined for this report, but when no mill opacifier was present, the consistent discrepancy between the values of reflectivity determined by the two methods disappeared. Either of these methods is somewhat simpler to carry out than the contrast-ratio method, and either gives a theoretical curve which fits the data satisfactorily within the commercial range of thickness.

The reflectivity method has proved to be more reproducible and somewhat simpler and, following coöperative work with the National Bureau of Standards, was adopted as a standard research method by the Porcelain Enamel Institute.[6]

In addition to the sources of error already discussed, it is possible to measure only the apparent reflectance of a specimen relative to a magnesium-oxide standard under given conditions of illumination and viewing. Such reflectances were used on the assumption that they represent adequate evaluations of reflectance, R. An enamel undergoes continuous change in the firing process, and some degree of interpenetration between ground coat and cover coat occurs.

All sources of error considered, the fit of the theoretical curves to data obtained by careful work under any of the three methods of determining the constants seems to be all that could be expected. Because each of the two Kubelka-Munk constants has a physical significance, as revealed in the respective definitions, the results give a basis of comparing different enamels and mill batches and of determining the character of effects produced by given changes in enamels or mill batches, which promises to be useful in the field of vitreous enamels.

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[5] G. H. McIntyre, "Graphical Computation of Opacity of Porcelain Enamels," *Jour. Amer. Ceram. Soc.*, **17** [10] 300 (1934).

[6] Porcelain Enamel Institute, "Reflectance Test for Opaque White Porcelain Enamels," 612 N. Michigan Ave., Chicago, Ill.

STUDY OF METALLOGRAPHIC CHARACTERISTICS AND ENAMELING QUALITIES OF CERTAIN CAST IRONS*

By R. B. Schaal

Abstract

The enameling properties of three different irons are described and their analyses are given. Photomicrographs are shown, depicting the structure of each iron near the surface before and after enameling. Structural changes during enameling are described and discussed as to their possible influence on enameling properties. It is shown that one iron anneals perfectly during enameling with no apparent surface alteration, another anneals perfectly but shows surface decarburization; the third sample does not anneal perfectly. Sample No. 1 enamels better than either No. 2 or No. 3.

I. Introduction

(1) Castings Characteristics

Three castings, obtained from widely separated foundries, exhibited rather characteristic differences in enameling behavior.

Casting No. 1 enamels well in a one-coat color applied directly to the iron and also takes reworking well. The enameled surface of the iron from this foundry shows a minimum of blisters and fire marks. This iron enamels well in two coats of white over ground.

Casting No. 2 does not take the enamel satisfactorily for direct application which worked so well on casting No. 1. The defects are crusted areas of blisters, which are aggravated by additional firing. These blistered areas are interspersed with comparatively good areas indiscriminately. Enameled in ground coat, the general appearance is satisfactory, but in the first cover coat deep craterlike pits appear, scattered singly over the entire area. In the second cover coat, deep pits of the same character appear. Some of the pits in the first coat are covered, others remain pitted in the second coat, and new craterlike pits appear.

Casting No. 3 does not take the one-coat direct application well. The defects are areas of small blisters and pits, especially on flat surfaces. A second coat of the direct enamel covers many of

Table I

Enameling Qualities

	Casting No. 1	Casting No. 2	Casting No. 3	
1 coat direct	Good	Bad blisters	Blisters	
2 coats direct	"	" "	Fair	
Ground coat	"	Good	Good	
1st cover coat	"	Pits	Fair	
2nd cover coat	"	"	Good	
Analysis before enameling				
Si	2.13	2.38	2.13	
Mn	0.67	0.49	0.58	
P	0.55	0.30	0.776	
S	0.085	0.080	0.078	
TC	3.43	3.28	3.38	
GC*	3.00	2.96	2.87	
CC†	0.43	0.32	0.51	
Analysis after enameling (carbon only)				
TC	3.36	3.34	3.37	
GC*	3.34	3.31	3.26	
CE	0.02	0.03	0.11	
Probable condition CE = TC + 0.3(Si + P)				
CE	4.23 eutectic	4.23 eutectic	4.34 eutectic	4.30 = eutectic

GC = graphitic carbon. TC = total carbon.
CE = carbon equivalent. CC = combined carbon.

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* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 23, 1937 (Enamel Division). Received February 24, 1937.

these defects, the ware being passable in two coats. The casting enamels well in a ground coat and two white cover coats.

The enameling results and analyses of castings are summarized in Table I.

II. Analysis of Castings

Figure 1 shows photomicrographs of casting No. 1 before and after enameling. (*A*) is the original structure at 100 diameters at the surface; (*B*) is the same at 500 diameters; (*C*) is the structure after enameling at 100 diameters; while (*D*) is the enameled casting at 500 diameters.

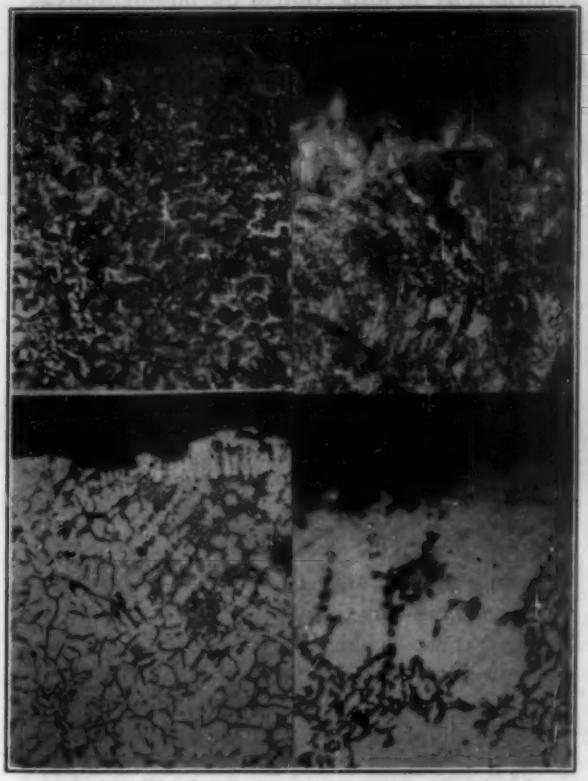

FIG. 1.—(*Upper left*) 1(*A*), original structure, 100×; (*upper right*) 1(*B*), original structure, 500×; (*lower left*) 1(*C*) structure after enameling, 100×; (*lower right*) 1(*D*) structure after enameling, 500×.

Figure 2 shows a like arrangement of photomicrographs for casting No. 2, and Fig. 3 represents casting No. 3.

The section thickness of casting No. 1 averages about $^{3}/_{16}$ inch; that of No. 2 is about $^{5}/_{32}$ inch; No. 3 is about $^{7}/_{64}$ inch.

It is to be regretted that no data of the history of any of these castings are available, so that this discussion must be confined to the data at hand.

A consideration of the probable soundness of the castings from the analyses and sections reveals that (1) because the section of this casting is about 15% thicker than No. 2 and about 40% thicker than No. 3, the iron at pouring could be lower in temperature or lower in intrinsic fluidity than either of the others (or both) with equal results. (2) Manganese promotes soundness by its usual function of combining to render the sulfides less harmful and by its effect as a degasifier or deoxidizer. There is 37% more manganese in casting No. 1 than in No. 2, and 15% more than in No. 3. The amount of manganese is seen to be in order of enameling properties. (3) Fluidity is promoted by increasing amounts of phosphorus, carbon, and silicon, probably in the order named. It is seen that as to phosphorus, casting No. 1 contains 80% more phosphorus than casting No. 2 and 12% less than casting No. 3.

FIG. 2.—(*Upper left and right*), 2(*A*) and 2(*B*); (*lower left and right*), 2(*C*) and 2(*D*).

Casting No. 1 contains about 5% more carbon than casting No. 2 and a trifle more than No. 3.

Silicon is highest in casting No. 2 by about 12%.

A consideration of the analytical features would indicate that probably the iron in No. 3 is intrinsically slightly higher in fluidity than in No. 1, but that in No. 2 it is well below both in this respect.

If these considerations are applied to the casting sections, it is concluded that casting No. 1 has the greatest pouring fluidity and the best chance of soundness; casting No. 3 is next, but, owing to the thin section, well below No. 1; while No. 2, with the least manganese, the least intrinsic fluidity, and an intermediate section, has the least chance for soundness.

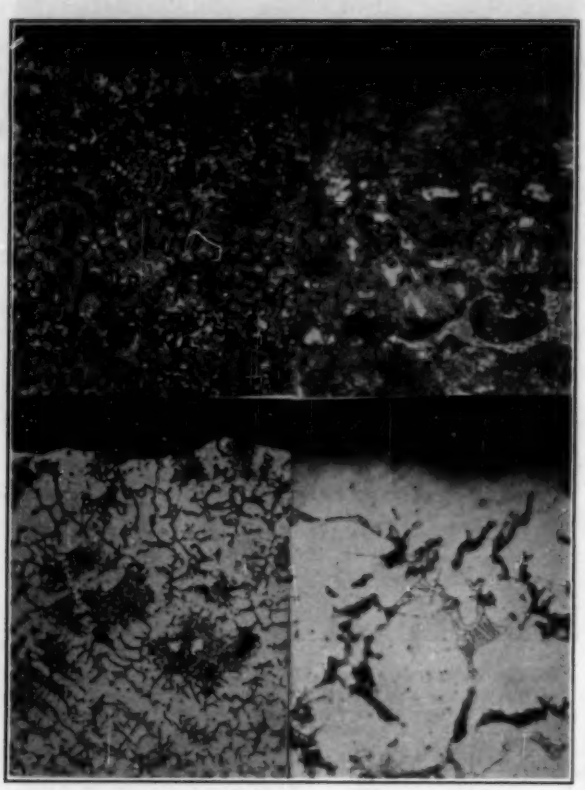

FIG. 3.—(*Upper left and right*), 3(*A*) and 3(*B*); (*lower left and right*), 3(*C*) and 3(*D*).

Comparing these deductions to the surface of the castings, as shown by the photomicrographs before enameling, this idea is thought to be well substantiated. The surface of No. 1 is fairly sound and highly pearlitic; that of No. 2 is porous and of irregular structure; and No. 3 has a slightly sounder surface than No. 2 but is largely composed of ferrite and phosphide eutectic.

The unsoundness of surface appears as minute holes, possibly blowholes, either from gases formed in the metal or from the mold penetrating the thin skin which first solidifies. It is such surface and subsurface porosity which is so difficult to open up thoroughly on sandblasting.

The probable resistance of the surfaces to reactivity, judging both from the enameling results and photomicrographs, is 1–3–2. That the surfaces actually have behaved in this order is rather well confirmed by an inspection of the photographs after enameling.

Figure 1 (*C*) shows the same general characteristics as 1 (*A*) except that the annealing action of enameling has changed the pearlite throughout. The surface is not much decarburized, and the graphite nest structure at the surface is preserved. This also is shown in Fig. 1 (*D*).

In Fig. 2 (*C*), the surface is decarburized completely and a considerable reaction must have taken place to produce this difference.

The surface of Fig. 3 (*C*) shows little change from 3 (*A*), except that much of the porosity is gone. That there is some surface alteration is shown by comparing Figs. 3 (*D*) and 1 (*D*), as well as certain spots of 3 (*C*) with the original 3 (*A*) and with 1 (*C*).

III. Conclusions

From a consideration of the evidence, although much weakened by the absence of a history of the castings, it is concluded that the surface condition has a decided bearing upon the enameling qualities of these castings.

It seems probable also that the intrinsic fluidity of the iron, related to the thickness of the casting poured, has a relation to this surface condition.

If this be admitted, the better enameling irons are probably those in which the manganese, phosphorus, and carbon contents are high and whose silicon is properly proportioned to the section to be cast.

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THE THEORY OF PHOTOELASTICITY*

By Hans Mueller

Abstract

The photoelastic birefringence of solids is caused by the superposition of two effects. An elastic deformation changes the arrangement of the atoms. If the deformation is a simple strain, this effect produces negative birefringence which increases with increasing refractive index of the solid. The second effect is due to a deformation of the atoms. A strain creates optical anisotropy of the atoms and causes positive birefringence. In most glasses the second effect is predominant, but for glasses with a large index of refraction the first effect takes precedence.

I. Introduction

A glass or a cubic crystal becomes birefringent if it is subjected to mechanical stresses. This so-called "photoelastic effect" can be described as follows: In the undeformed state, the index of refraction, n, of an isotropic solid is independent of the direction of polarization of the light. If the medium is under the influence of a pressure, p, the light polarized parallel to the direction of pressure has a different refractive index than light polarized normal thereto. The refractive index for light which oscillates parallel to the pressure (*i.e.*, polarized normal to p) is denoted with n_p, and the refractive index for light oscillating normal to p, with n_n. Measurements have shown that $n_p - n$, $n_n - n$, and also the birefringence, $n_n - n_p$, are proportional to the pressure. The ratio, $(n_n - n_p)/p = B$, is called the photoelastic or the stress-optical constant of the material.

II. Strain, Not Stress, as Cause of Photoelasticity

From a theoretical point of view it seems more reasonable to consider the elastic deformations or the strains, and not the stresses, as the real cause of photoelasticity, because it is inconceivable how a pressure could change the optical properties of a glass if the stresses did not create deformations. Let us consider the birefringence which would be produced by stretching a bar of length, l, by a short amount, dl, without permitting any crosswise contraction. Although such a deformation has never been performed experimentally, the birefringence which it would produce can be calculated. If n_p and n_n are the refractive indices for light oscillating parallel and normal to the strain, $S = dl/l$, then $(n_p - n_n)/S = b = EB/(1 + \sigma)$. E is Young's modulus and σ is Poisson's ratio. The strain-optical constant of the material is called b. It is related to Neumann's strain-optical constants, p and q, according to the relation, $b = (p - q)n^2$. A strain produces positive or negative birefringence depending on the sign of b.

The fact that the birefringence is proportional to the strains and stresses has made photoelasticity a valuable tool for investigating stress distributions and the problem of annealing.

III. Atomistic and Photoelastic Properties

The origin of photoelasticity from the point of view of atomistic theory is given here. If the structure of a substance, its chemical composition, and the arrangement and the properties of its molecules, atoms, and ions are known, one should be able to calculate the value of the strain-optical constant, b; *vice versa*, if such a theory can be given, measurements of the photoelastic properties of a material will give information concerning its atomistic structure.

Of all transparent substances, the cubic crystals of NaCl and KCl are those whose structure and atomistic properties are most accurately known. It is therefore natural that the first significant[1] attempts at a theory of photoelasticity were made for these crystals. Herzfeld[2] and Banerjee[3] published two independent calculations of the effect. Although both authors used exactly the same physical assumptions, they reached entirely differ-

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 24, 1937 (Glass Division). Received May 31, 1937.

[1] Earlier attempts of (*a*) W. Voigt, "Beiträge z. Elektronentheorie des Lichtes," *Ann. Physik*, **6**, 459–505 (1901); (*b*) H. Ambronn, "Über akzidentelle Doppelbrechung," *Goettinger Nachrichten*, **2**, 299–320 (1919); and (*c*) O. Wiener, "Zur Theorie der Refraktionskonstanten," *Ber. deut. ges. Wiss.* [Leipzig], **62**, 255–77 (1910) must be discarded because they are based on assumptions concerning the structure of matter which are now antiquated.

[2] (*a*) K. F. Herzfeld, "Theory of Forced Double Refraction," *Jour. Optical Soc. Amer.*, **17**, 26–36 (1928).
(*b*) K. F. Herzfeld and R. H. Lee, "Theory of Forced Double Refraction," *Phys. Rev.*, **44**, 625–31 (1933).

[3] K. R. Banerjee, "Theory of Photoelasticity," *Ind. Jour. Phys.*, **2**, 195–242 (1927).

ent conclusions. Unfortunately both papers contain mathematical errors[4] which invalidate all of their conclusions. Nevertheless, their work is noteworthy, because it furnished one of the important principles for the explanation of photoelasticity.

Herzfeld and Banerjee postulated that the photoelastic birefringence has the same origin as the natural double refraction of anisotropic crystals. If a cubic crystal of the type NaCl is strained normal to a cube face, it will become a tetragonal crystal and will be birefringent. Although this argument is unquestionably correct, it is not sufficient to explain the observations. In the stretched state, the atoms in the lattice planes normal to the strain have the same separations as in the original state, but these planes have moved farther apart from each other. Hence the strained crystal is a layer lattice and should show negative birefringence because all natural layer lattices (*e.g.*, mica) are negatively doubly refracting. The measurements of the photoelastic effect of NaCl and of most other cubic crystals, however, give the opposite result. They lead to a positive value of b, which means that a strain creates positive birefringence.

IV. Lattice and Atomic Effects

It is therefore obvious that the theory of Herzfeld and Banerjee can not be a complete solution of the problem. On the other hand, it can not be disregarded because it is based on sound physical principles. The solution, then, of this dilemma must be found by assuming that, in addition to the "lattice-effect" considered, there must exist a second effect which contributes to the photoelastic birefringence. Because the lattice effect takes into consideration all optical changes produced by the change of the arrangement of the atoms, the second effect is connected with a change of the structure of the atoms. It is therefore called the "atomic effect." There is a fundamental difference between natural and forced birefringence. In a naturally birefringent crystal, every atom is in its "natural surroundings." Its nearest neighbors and their distances are determined by its own properties, size, and chemical affinities and by the sizes and the valencies of its neighbors. In an elastically deformed solid, on the other hand, the arrangement of the nearest neighbors is slightly distorted, some chemical bonds being weakened and others strengthened. It seems quite natural, therefore, to assume that under these circumstances the electronic structure of every atom will be slightly altered.

It should be possible to calculate the optical changes due to this atomic effect with the help of wave mechanics. Unfortunately, this problem is extremely complicated. A solution can not be expected very soon because the electron distributions in transparent solids are not known even for the undeformed state of the crystals. In spite of these difficulties, the assumption that photoelasticity is the result of two effects can be shown to be essentially correct. The procedure is as follows: The lattice effect is calculated and the results are compared with the observations. The difference between the calculated and the observed values of the strain-optical constant is interpreted as the contribution due to the atomic effect. This atomic contribution is shown to be of a reasonable order of magnitude, and its variation with the chemical composition of the material agrees with the expectations based on other known properties of the atoms.

V. Basic Assumptions and Calculations

The basic assumptions and the calculations for amorphous solids for which the mathematical procedure is considerably simplified will be outlined here.

NOTE: For the analogous calculation for cubic crystals, the reader is referred to the article by the writer in *Phys. Rev.* (see footnote 4).

According to the theory of refraction of H. A. Lorentz and L. Lorenz, a light wave creates a periodic electric field, F, which acts upon the electrons and nuclei of the molecules. These particles of opposite charges are shifted in opposite directions; thus every molecule becomes an oscillating electric dipole with the moment, $m = \alpha F$. The polarizability, α, is a characteristic constant for each atom, molecule, or ion. The inner field, F, at any point is made up of two parts. One part is the field, E, which the light wave would create if it were traveling through a vacuum. The second part is the field produced by the dipoles of all the molecules except the one at the point considered. According to H. A. Lorentz, the calculation of this second field can be carried out by dividing all the dipoles into two groups, as shown in Fig. 1.

[4] Hans Mueller, "Theory of Photoelastic Effect of Cubic Crystals," *Phys. Rev.*, **47**, 947–57 (1935).

The first group includes all dipoles which are in the neighborhood of the arbitrarily chosen molecule, *i.e.*, they are within a small sphere which has the chosen molecule as its center. The second

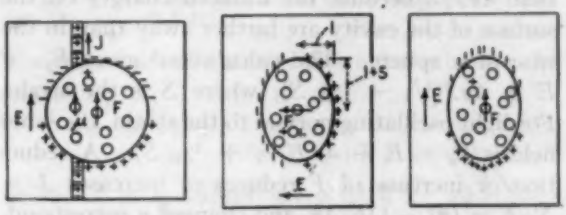

FIG. 1.—Calculation of the inner field, F, in a homogeneous glass (*left*) and in a strained glass (*middle and right*). The electric field, due to the dipoles within the spherical or ellipsoidal cavity, in all three cases is zero. The field of all other dipoles can be calculated from the distribution of the induced charges on the surface of the cavities.

group of molecules, comprising all those which are outside the sphere, are so far away that they will act as if they formed a continuous distribution of matter. If N is the number of molecules per cubic centimeter, this "continuum" has an average polarization, $J = Nm$, and a simple calculation gives $4\pi J/3$ as its contribution to the field, F. This result is correct for amorphous or crystalline and isotropic or anisotropic solids. In calculating the electric field of the dipoles of the first group, however, one must know the arrangement of the nearest atoms. In general, the calculation of this field is rather complicated. The results depend on the crystal structure and the direction of polarization of the light. The result is simple only for cubic crystals and for amorphous solids, if it is assumed that neighboring atoms can form any random arrangement. In these two types of substances, the field of the neighboring molecules is zero; then the total field is $F = E + 4\pi J/3$. Since $J = (n^2 - 1)\,E/4\pi$, upon eliminating F and J, the well-known Lorentz-Lorenz equation is found as follows:

$$(n^2 - 1)/(n^2 + 2) = \frac{4\pi}{3} N\alpha.$$

If the substance contains different kinds of atoms, the following equation is obtained:

$$R = \left(\frac{n^2 - 1}{n^2 + 2}\right)\frac{1}{\rho} = \sum \gamma_i R_i \qquad (1)$$

Where γ_i = molar concentrations.
ρ = density.
$R_i = \frac{4\pi}{3} \nu\alpha_i$ = molar refraction.
ν = Avogadro's number.

VI. Refraction Due to Oxygen Ions

With the help of equation (1), the refractions and polarizabilities of the atoms can be determined from the density and the index of refraction of gases, liquids, or cubic crystals. From the work of Wasastjerna and Fajans, Joos,[5] and others, these values are known for a large number of ions and molecules. It is found that R increases with the size of the ions. Furthermore, R is large for negative and small for positive ions. For instance, for the O^{--} ion, $R_O = 7$, while for Si^{++++}, $R_{Si} = 0.1$. Consequently, in a SiO_2 glass, the contribution to the refraction due to the oxygen ions is about 140 times larger than that due to the Si ions.

VII. Lorentz Equation Valid for Glass

For silica glasses, Warren[6] has found that every Si ion is tetrahedrally surrounded by four O ions and every O ion is shared between two tetrahedral groups. The arrangement, therefore, of nearest neighboring atoms is not a random one, and the condition for the applicability of the Lorentz-Lorenz equation seems scarcely to be satisfied. But because the Si ions give a negligible contribution to the refraction, only the arrangement of the O ions is of interest. Warren's nonrepeating network structure of glasses does not require any regular order in the position of the O ions, and it seems, therefore, that the Lorentz-Lorenz equation should be valid for glasses. Figure 2 shows that this conclusion is supported by the experimental evidence. The refraction of a series of lead glasses is plotted as a function of the molar concentration of oxygen or Pb ions, and the graph verifies the linear relationship,

$$R = \gamma_o R_o + \gamma_{Pb} R_{Pb}$$

as required by equation (1). Thus the assumption is justified that, in a glass, the average distribution of those atoms which contribute to the refraction is a random one.

[5] (*a*) J. A. Wasastjerna, "Über die Bau die Atome im Licht der Dispersions-Theorie," *Z. physik. Chem.*, **101**, 193–217 (1922).
(*b*) K. Fajans and G. Joos, "Molrefraktionen von Ionen, etc.," *Z. Physik*, **23**, 1–47 (1924).
More recent values of the refractions and polarizabilities by (*c*) C. P. Smyth, Dielectric Constant and Molecular Structure, Chemical Catalog Co., 1931, and by (*d*) J. Van Vleck, Electric and Magnetic Polarizabilities, Oxford Univ. Press, 1932.

[6] (*a*) B. E. Warren, "Diffraction of X-Rays in Glass," *Phys. Rev.*, **45** [10] 657–61 (1934); *Ceram. Abs.*, **13** [11] 289 (1934).
(*b*) B. E. Warren, "X-Ray Determination of Structure of Glass," *Jour. Amer. Ceram. Soc.*, **17** [8] 249–54 (1934).

VIII. Calculation of Lattice Effect

If a substance with an isotropic distribution of atoms is strained, the distribution becomes anisotropic. The average distance between neighboring atoms becomes larger in the direction of strain, while it does not change in the directions normal

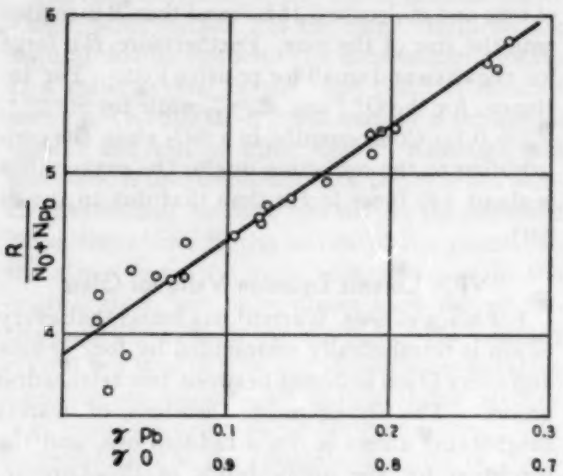

FIG. 2.—Showing the validity of the Lorentz-Lorenz equation for lead glasses. R is the measured refraction minus the small refractions due to the cations Si, B, Al, K, Na, As. N_O and N_{Pb} are the number of mols of oxygen and lead ions in one gram of glass. The intersect with the axes shows that the molar refraction of O^{--} is $R_O = 3.9$.

to it. The electric field due the neighboring atoms, therefore, will not vanish in the strained glass, and its magnitude will depend on whether the light oscillates parallel or normal to the strain. It is this difference of the inner fields, F, for the two light components which is responsible for the "lattice effect" of photoelasticity.

The calculation of the electric field produced by an anisotropic distribution of dipoles within a spherical cavity is a rather complicated task. It can be avoided by using a slightly modified procedure which was first suggested by Havelock.[7] By straining the glass, the spherical cavity which incloses the dipoles of the first group is deformed into an ellipsoid of rotation, as shown in Fig. 1. The atoms in the ellipsoid are, of course, displaced, but it turns out that for small strains the field due to all dipoles in the ellipsoid remains zero. Thus, the same procedure can be used as in the derivation of the Lorentz-Lorenz equation if $4\pi J/3$ is replaced by the well-known expression for the field in the center of an ellipsoidal cavity surrounded by a uniformly polarized medium. If the light, and hence the polarization, J, oscillates parallel to the strain, this field is, of course, smaller than $4\pi J/3$ because the induced charges on the surface of the cavity are farther away than in the case of a sphere. The calcu'ation[8] gives $F_p = E + 4\pi J(1/3 - 4/15\, S)$, where S is the strain. For light oscillating normal to the strain, the inner field is $F_n = E + 4\pi J(1/3 + 2/15\, S)$. A reduction or increase of F reduces or increases $J = N\alpha F = (n^2-1)E/4\pi$, and changes n correspondingly. Since a strain reduces the density of the glass, both n_n and n_p are smaller than n, but the result, $F_n > F_p$, is responsible for the fact that $n_n > n_p$. The computation gives

$$n_p - n_n = -S(n^2-1)^2/6\, n = Sb.^*$$

* Indicates that this is a theoretical value which takes into account only the lattice effect.

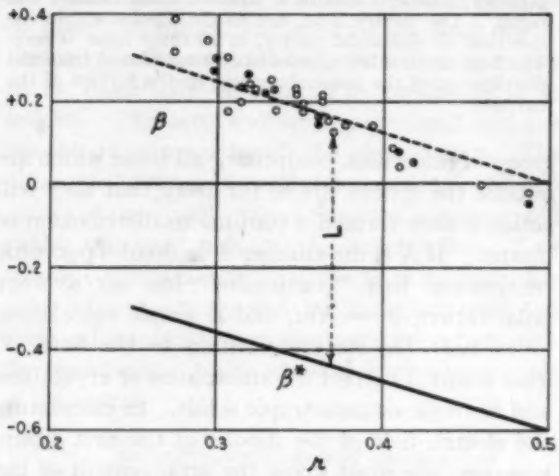

FIG. 3.—Comparison of the experimental values of the photoelastic constant, β, with the theoretical value, β,* derived from the "lattice effect." The experimental values are calculated from the data of Pockels (*full circles*), Adams and Williamson (*half-filled circles*), Filon, and others.

This confirms the previous statement that a strain should produce negative birefringence if photoelasticity were caused only by the anisotropic arrangement of the atoms. The magnitude of the "lattice effect" depends only on the refractive index of the undeformed glass. The calculation and observations may be compared by plotting the measured values of b against n. A more convenient method of comparison is obtained by

[7] T. H. Havelock, "Dispersion of Double Refraction in Relation to Crystal Structure," *Proc. Roy. Soc.* [London], **A80**, 28–44 (1908).

[8] Hans Mueller, "Theory of Photoelasticity in Amorphous Solids," *Physics*, **6**, 179–84 (1935).

chosing as independent variable the refraction, $r = (n^2 - 1)/(n^2 + 2)$. The equation is therefore written in the form

$$\beta^* = 6nb^*/(n^2 - 1)(n^2 + 2) = -6r/5. \quad (2)$$

* Indicates a theoretical value which takes into account only the lattice effect.

The experimental value of β is obtained from the relations

$$\beta = 6n^3(p - q)/(n^2 - 1)(n^2 + 2) = 6EBn/(1 + \sigma)(n^2 - 1)(n^2 + 2).$$

In Fig. 3, these values[9] are plotted for all glasses for which B, E, σ, and n are known. This figure reveals that the observed photoelastic constant, β, is indeed a simple function of the refraction, r, of the glass. But this function does not coincide with the linear relation, $\beta^* = -6r/5$, which results from the lattice effect. While this effect predicts large negative values, the experiments give positive or very small negative values, but the average slope of the experimental curve agrees fairly well with the slope of the theoretical straight line. In accordance with the introductory remarks, it is concluded that the atomic effect gives for all glasses approximately the same positive contribution of 0.6 to the value of β.

A quite analogous result is obtained by comparing the lattice effect with the observed values of β for a strain normal to the cube face of NaCl and KCl. Here the values[10] for NaCl are $\beta = 0.118$, $\beta^* = -0.946$, for KCl, $\beta = -0.155$, $\beta^* = -1.245$, and the atomic effect gives a contribution of 1.064 for NaCl and 1.090 for KCl. Again the atomic effect is almost the same for both crystals.

IX. Atomic Effect Due to Deformability of Oxygen Ions

The refraction in glasses has been shown to be largely due to the O ions. Similarly in NaCl and KCl, the refraction receives its main contribution from the Cl ions. There is reason, therefore, to suspect that the magnitude of the atomic effect is related to some specific properties of the O and Cl ions.

The final clue which reveals the physical nature of the atomic effect is furnished by the photoelastic behavior of NaCl and KCl crystals when they are subjected to a shearing strain. Calculation of the lattice effect produced by a shear gives for KCl a result which agrees with the measured value. Thus a shear does not create an atomic effect in KCl. For NaCl, however, the observations can be explained only by assuming the existence of an atomic effect due to shearing. The origin and significance of this result can be understood with the help of Fig. 4. In KCl, the two kinds of ions, K^+ and Cl^-, are nearly of equal size. A shear produces a sliding of one layer of atoms over another. The figure shows that this operation can be performed without changing the form of the atoms if they are of equal size. In NaCl, however, the Na ion has a smaller radius than the Cl ion, and the situation is more nearly that shown on the right side of Fig. 4. If the ions are of different sizes, a shear produces a squeezing of the larger ion. In the sheared state of NaCl, the

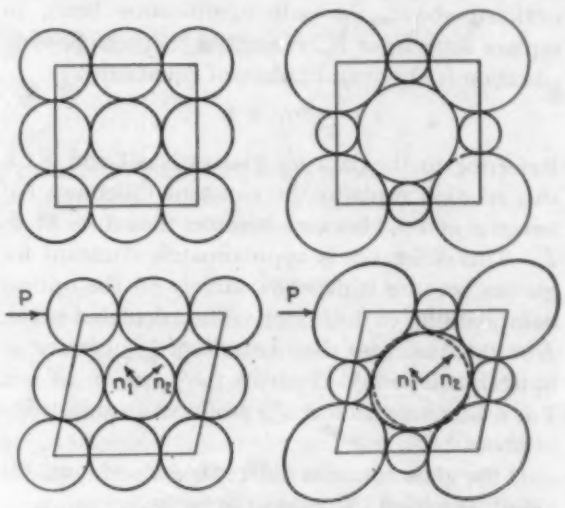

FIG. 4.—Influence of a shear on the structure of a cubic crystal of the type NaCl: (*upper figures*), undeformed states; (*lower figures*) sheared states; (*left*) anion and cation have the same size; a shear does not deform the ions; (*right*) the anions are much larger than the cations; a shear produces deformation and optical anisotropy of the anions.

Cl ion becomes deformed, *i.e.*, the distributions and motions of its outermost electrons are changed. The outermost or optical electrons of an atom determine its polarizability and atomic refraction. The conclusion is reached that the atomic effect of photoelasticity is due to the deformation of the atoms or ions caused by an elastic deformation of the solid.

If the deformation of a glass or of a cubic crystal is a simple strain, $S = \frac{dl}{l}$, the atoms will

[9] A list of all the data used can be found in *Physics*, **6**, 183 (1935).

[10] For ionic crystals, the calculations include the effect of the ionic charges on the polarizabilities; see footnote 4, p. 28.

expand slightly in the direction of strain. The atoms or ions become optically anisotropic, *i.e.*, the refraction of each atom will be larger for light oscillating parallel to the strain than for light oscillating normal to S. The atomic effect then must give a positive contribution to the strain optical constant and to β, which agrees with the observations. If R_p and R_n are the refractions of an atom for light oscillating parallel and normal to the strain, the optical anisotropy, $R_p - R_n$, will be proportional to the strain, which gives the following equation:

$$R_p - R_n = L\,S\,R$$

Where L = a characteristic constant for each atom and might be called its optical deformability.

For a strain of 1%, the optical anisotropy is L% of the original refraction, R.

If the calculation of n_n and n_p is repeated, as outlined above, the only modification being to replace R by R_n or R_p, respectively, the following equation is obtained in place of equation (2):

$$\beta = -6r/5 + L \qquad (3)$$

Referring to the data for glasses NaCl and KCl, this relation explains the constant difference between β and β,* because it states that $\beta - \beta^* = L$. This difference is approximately constant for glasses because it depends largely on the optical deformability of the O ions. The calculated value, $L = 0.6$, indicates that a strain of 1% creates an optical anisotropy of about 0.6% in an O ion. For a Cl ion a strain of 1% produces an anisotropy of about 1%.

If the glass contains different kinds of ions, the result, equation (3), takes the form

$$\beta = -6r/5 + \sum L_i c_i \qquad (4)$$

Where $c_i = \gamma_i R_i / R$, the percentage of total refraction due to the ions of the kind, i.

If the chemical constitution of a glass is known, c_i can be calculated by using the tables for R_i.

The data in Fig. 2 show that in lead glasses a part of the refraction is due to the Pb ions. Similarly, Fig. 3 shows that L is slightly smaller for heavy glasses than for quartz glass. Thus a more accurate representation of the results on glasses can be obtained by using the relation,

$$L = c_O L_O + c_{Pb} L_{Pb}.$$

Where c_O and c_{Pb} can be deduced from Fig. 2.
L = difference between theoretical and observed curves in Fig. 3.

Figure 5 shows that this relation is satisfied and gives $L_O = 0.65$, $L_{Pb} = 0.4$.

X. Deformation of Atoms Is Small

The order of magnitude of the atomic effect is quite reasonable. From the work of Fajans and Joos,[5] it is known that the ions do not always have the same refraction. It can vary by a few per cent, depending on the size and charge of the neighboring ions. To produce a change of 1% of the refraction with the help of strain, a strain of about 2% or a force of about ½ million pounds per square inch would be needed. In photoelastic experiments, therefore, the deformation of the atoms is very small. It would be difficult to observe it by any other means, for instance by X-rays. It manifests itself in the photoelastic effect, because the refraction adds together the effects of a large number of atoms.

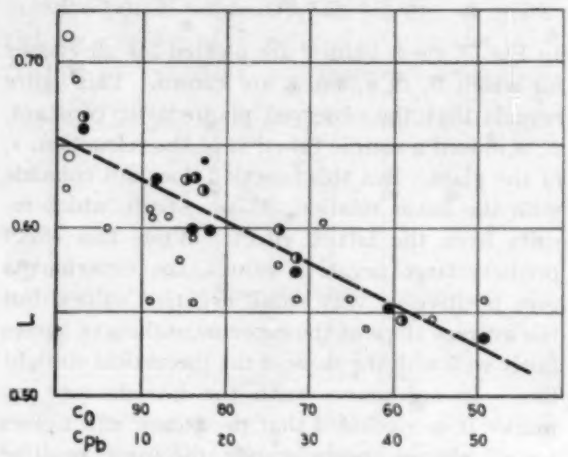

FIG. 5.—The "atomic" contribution, L, to the photoelastic constant, β, for lead glasses as function of the partial refractions of the O and Pb ions. L is derived from the data in Fig. 3, c_O and c_{Pb} from Fig. 2.

XI. Conclusions

The theory of photoelasticity presented here is qualitatively and quantitatively in agreement with the observations. It postulates that the birefringence has two causes, (1) the lattice effect due to the change of the arrangement of the atoms, and (2) the atomic effect due to the deformation of the atoms. The lattice effect alone produces negative birefringence in a strained solid. It increases with increasing index of refraction of the material. The atomic effect creates positive birefringence if the deformation is a simple strain.

It depends on the chemical constitution of the substance and shows but little variation. The number of reliable data for which the theory can be (and has been) verified is rather small, and it is probable that a larger number of more accurate data might require further refinement of the theory. One of the most satisfactory achievements of the theory is that it explains why glasses with a small index of refraction have a positive, and heavy glasses have a negative photoelastic constant. In light glasses, the lattice effect is small and the atomic effect determines the sign of B and b. In heavy flints, the lattice effect is predominant and the constants are negative.

Since the photoelastic effect is so closely related to the refractive index, it can not give any more information about the atomistic structure than can be obtained from measurements of the index. This theory is in agreement with Warren's analysis of the structure of glasses. It confirms his work insofar as it excludes the existence of large crystalline groups. If such groups would exist, the present calculation of the lattice effect would have to be considerably modified. Any effect which creates a more ordered arrangement of the oxygen ions in glasses would alter the photoelastic constants. It seems possible that Filon's[11] observation that the photoelastic constants vary with the age of a glass is due to an effect of this kind.

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[11] E. G. Cocker and L. N. G. Filon, Photoelasticity, Cambridge Univ. Press, 1931.

AN INSTRUMENT FOR MEASURING THE WORKABILITY OF CLAYS*

By F. H. Norton

Abstract

An instrument is described for measuring quantitatively the workability of clays, using the principle of twisting rapidly a tubular test specimen and recording the stress-strain diagram. Some results are given to indicate the value of this instrument.

I. Introduction

The ceramic industry has long needed some means of measuring quantitatively the workability of clays and bodies. The work carried out by Wilson[1] showed that significant results were obtained by a torsion specimen twisted at a comparatively high rate of speed. This apparatus, however, was not entirely satisfactory because the solid specimen used was not in uniform shear, causing the important points in the diagram to be obscured, and the correction necessary to convert the diagram to consistent scales was rather laborious. A new piece of apparatus was therefore constructed, using the same principle but employing a tubular test specimen of somewhat larger size and forming a diagram which required no corrections. This apparatus has been in use for about one year, and it seems to be capable of giving comparatively precise results on the workability of ceramic materials.

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[1] E. O. Wilson, "Plasticity of Finely Ground Minerals with Water," *Jour. Amer. Ceram. Soc.*, **19** [4] 115–20 (1936).

II. Apparatus

The specimen used in this test consists of a tube of $^5/_8$ inch inside diameter and $^7/_8$ inch outside diameter, with a gage length of 2 inches between the brass ends. The specimens are formed in a small vacuum auger extruding the clay tube vertically downward. Four-inch sections of this tube are cut off with a wire and held lightly between the halves of a plaster mold, in the ends of which are inserted brass holders made of square tubing 1 inch across the outside faces and $^1/_{16}$ inch thick. The clay is forced tightly into these square end pieces which hold the ends rigidly and leave the free center section undistorted. After forming in this manner, one-half of the plaster mold is removed, and a temporary brass bar is attached between the brass end pieces with small screws so that the specimen can be handled thereafter without straining it, even though its consistency is soft. This bar is later removed after the specimen is securely clamped in the testing machine.

The testing machine itself is shown in Fig. 1. The specimen, B, with its brass end pieces, is clamped in the torsion head, C, by means of a

wedge, as shown more clearly in the detailed sketch. This offers a simple and secure locking device which prevents any backlash during the test. This torsion head is rotated by the motor, *D*, through the reduction gear, *E*, the flexible couplings, *F*, and the gears, *G*. The motor and reduction unit are mounted on spring suspensions, *H*, to prevent any vibration from being transmitted to the remainder of the apparatus.

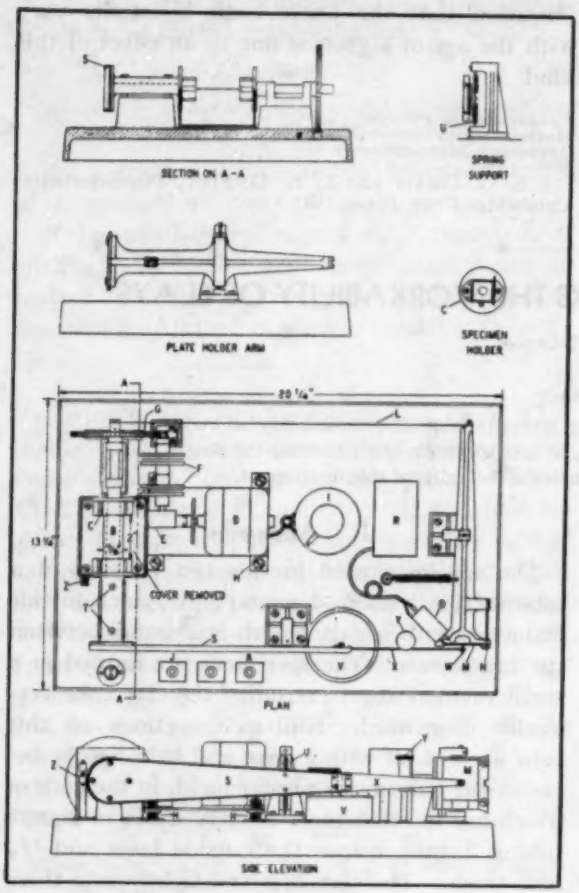

FIG. 1.

This drive gives a constant speed with sufficient power for any of the tests with plastic materials. The speed of the motor can be altered by the voltage regulator, *I*, and its direction is reversed by switches, *J* and *K*, which independently control the separate field coils. In addition, the speed may be changed by various sets of gears at *G*.

The angle of rotation of the specimen is recorded by the steel tape, *L*, one end of which is wound around a drum on the torque shaft, and the other attached to the plate-holder arm, so that the angular rotation is proportional to the movement of the smoked plate, *M*. This plate is held in a spring clip, *N*, and is illuminated from the back by the light, *O*, supplied by the 6-volt transformer, *R*. This illumination is necessary for close observation of the stylus in relation to the zero line, as will be described later.

The torque on the specimen is measured by the deflection of the light aluminum arm, *S*, which is pivoted on the center line of the specimen with the flexible steel Emery knife edges, *T*. The deflection of the end of the arm is, therefore, free from any friction effects and is proportional to the torque. In the case of the stiffer materials, the springs, *U*, are necessary to supplement the knife edges. Under these conditions, the vertical movement of the end of the arm, *S*, is proportional to the torque for the small angles employed. The movement of *S* is controlled by the dash pot, *V*, filled with a light oil of a viscosity to give critical damping. Such damping is necessary when rapid movements of the arm occur in the initial portion of the stress-strain diagram.

The recording of the diagram takes place on the smoked glass plate, *M*, by means of a pointed steel stylus, *W*, held against the plate lightly by the thin steel spring, *X*, so that very little friction results. The stop, *Y*, allows the stylus to be removed from the smoked glass plate after the completion of a record.

III. Method of Making a Test

The general procedure in making a test is to place in the machine a smoked glass plate an to draw a horizontal line across the plate with the torque arm in its equilibrium position, that is, with no specimen in the holders. The torsion head is then rotated back to its zero position, which is indicated by a reference mark on the rim of the large gear. A specimen, which has been aged at least 24 hours, is placed in the holders, the wedges being carefully inserted to give a firm grip. The temporary cross-bar is then removed; this, of course, must not be neglected, because otherwise the machine would be seriously injured. To prevent such injury, there is a small stud on the under side of the cover of the specimen chamber which engages this cross-bar and prevents the cover from being dropped down in place; if the cover is not in place, the safety switch, *Z*, remains open and prevents the motor from being started. After removal of the cross-bar, the cover is put in place,

the light turned on, and the motor turned slowly by hand until the stylus, which is held a small distance away from the smoked glass, is at the exact level of the zero line, indicating that there is no

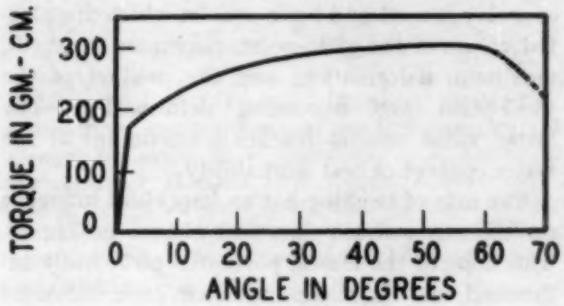

FIG. 2.

torsional strain in the specimen. This adjustment is necessary because the specimens have a small residual torsional stress after they have been placed in the machine. After this adjust-

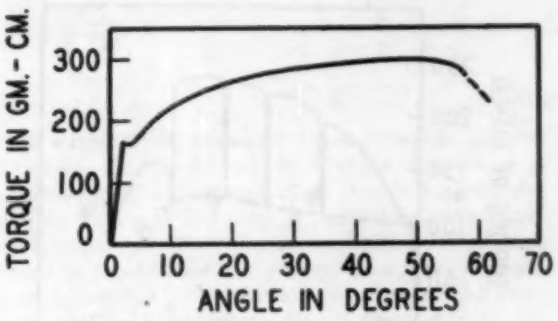

FIG. 3.

ment, the specimen should be allowed to rest 10 minutes for equilibrium before the actual test is started. After this period of time, the stylus is brought against the smoked glass and the switch, *K*, is closed, which rotates the head, *C*, and produces a stress-strain diagram at a comparatively high rate of speed. The rate of turning of *C* is usually 3 revolutions per minute, which roughly corresponds to the rate of working clay in the usual commercial machinery. Lower or higher speeds, however, can readily be used with a different adjustment.

After the diagram has been made, the smoked glass is put in a fixed focus enlarger and traced directly on a mimeographed sheet with a scale of the proper magnitude, so that no calculations are necessary to give the complete diagram. If more detailed records are needed, however, the enlargements can be made directly on bromide paper.

IV. Results

The specimens, no matter how carefully made, show some variation with the same batch of clay. This is undoubtedly due to small flaws which can not as yet be entirely avoided, especially in pieces of such small sections. It is found desirable, therefore, to run from 4 to 9 specimens under any one condition and to take the average. Occasionally a specimen will break at the ends and give quite distorted results; such a diagram is discarded. Typical results obtained on a single clay are shown in Table I.

TABLE I

Specimen No. 3	Yield point (gram-cm.)	Max. shear stress (gram-cm.)	Max. strain (degrees)
1	170	320	60
2	180	320	56
3	160	300	56
4	170	280	55
5	170	310	72
6	180	290	72
Av.	172	303	62
Av. deviation	5	13	6

The type of diagram produced for most clays is similar to that shown in Fig. 2, which is a typical diagram for an elastico-plastic solid. The initial portion up to the yield-point represents the elastic region, whereas the portion between the yield-point and the breaking point indicates plastic deformation. Some clays give a curve like that shown in Fig. 3, which indicates a definite yield-point with an actual dropping off in strength

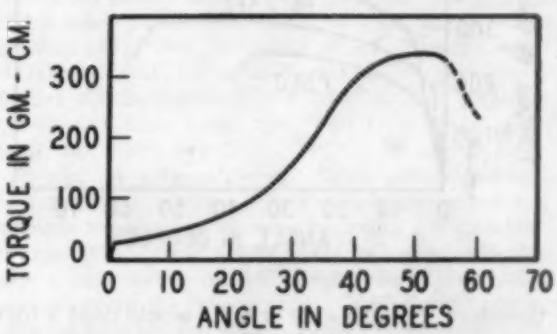

FIG. 4.

at that point. This curve is also characteristic of metals when tested in torsion. The reduction in strength may be attributed to thixotropy, and the subsequent increase in strength to strain

hardening. Some of the coarser grained china clays show the strain-hardening effect markedly as indicated in Fig. 4, where a low but definite

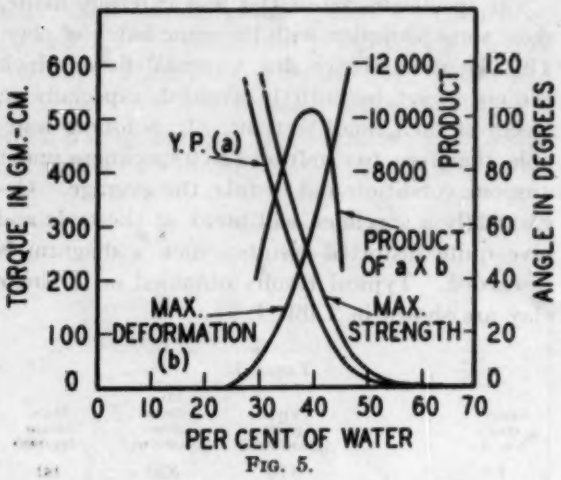

Fig. 5.

yield-point is changed by a gradual increase in strength up to the breaking point. Many slightly plastic materials such as bauxite, show this effect.

At least three properties must be used to express the workability of clay, *viz.*, yield-point, maximum strength, and deformation at the breaking point. The yield-point is important because it enables the formed clay article to retain its shape under gravitational forces and the sudden accelerations of handling. The maximum extensibility measures the degree with which the clay can be formed without rupture;

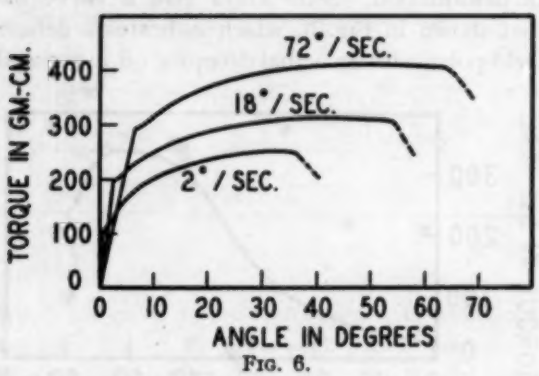

Fig. 6.

therefore, a plastic clay or body would need a high value of yield-point and a high extensibility. If the clay has a low yield-point, it will slump after working, and if it has a low extensibility it will be short and difficult to form. The maximum strength is used to determine the power required to work the clay.

In comparing two clays it is necessary, of course, to know their various characteristics at several water contents, in order to select that water content which gives the best workability. This is shown in Fig. 5, where the water content of a clay is used as a basis against which are plotted values of the yield-point, maximum strength, maximum deformation, and the product of the yield-point and maximum deformation. The latter value usually reaches a maximum at the water content of best workability.

The rate of twisting has an important influence on the stress-strain curve as shown in Fig. 6. The slope of the elastic portion is profoundly influenced, and the maximum extension is increased with increasing rate of shear. The resistance to plastic flow increases with the rate of shear, but the decrease in modulus of elasticity and increase in maximum extension require explanation. Forming operations of clay should take place rapidly to obtain the best results.

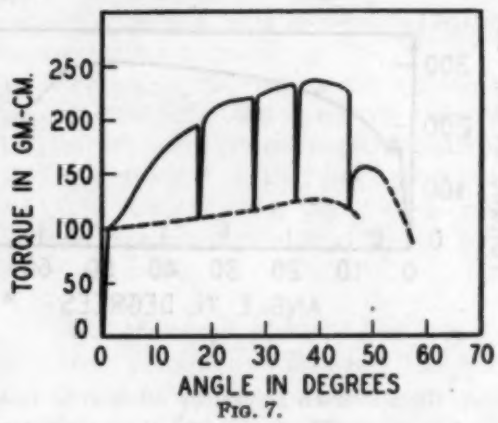

Fig. 7.

That a clay is truly elastic below certain stresses may be seen in Fig. 7. A specimen was run past the yield-point and allowed to rest for 15 minutes, during which interval the torque springs tended to restore it to its zero position by plastic flow. When the yield-point was reached, the clay was capable of supporting this load indefinitely. Additional increments of twist were given the specimen with intermediate rests, and each time the load came down to a steady value. Each increment, however, slightly raised the yield-point just as would happen with a piece of metal. The striking similarity is thus noted between elastico-plastic clay-water mixture and elastico-plastic metal.

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CERAMIC ABSTRACTS

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January, 1938

17—1

Abrasives

Abrasives in the foundry. Anon. *Abrasive Ind.*, **17** [5] 16–19 (1936).—A brief review of the manufacture of aluminum oxide and silicon carbide abrasives is presented with an outline of the scope of application of manufactured abrasives. The specific application of grinding wheels in the foundry is discussed from the standpoint of the abrasive, bond in the abrasive, type of work to be done, and kind of castings and metal to be cleaned. To obtain the lowest cost in grinding per unit of output, four factors must be considered, *viz.*, work produced, wheel cost, labor cost, and time consumed or overhead. F.J.Z.

Burnishing procedure for aluminum screw machine products. J. F. Coneen. *Metal Ind.* [N. Y.], **34**, 301 (Aug., 1936).—Type of equipment, materials, and proper procedure for obtaining a good burnish finish are described. C. discusses the necessity for correctly preparing the material before actual burnishing, proper selection of correct ball or cone sizes, and precautions against too large a load (likely to damage threads, etc.). H.K.R.

Canadian National grinds driving axle journals. M. M. McCall. *Iron Age*, **137** [20] 37–42 (1936). E.H.McC.

Early scratch hardness methods. S. R. Williams. *Instruments*, **10** [7] 182–84, 190 (1937).—W. discusses brittleness and plasticity as factors in scratch hardness testing and Mohs' classic method. *Ibid.*, [8] 208–209, 212.—Scratch hardness methods of Auerbach, Franz, Martens, and Hirschwald are described and compared. F.P.P.

Fields of application for precision grinding. C. O. Herb. *Machinery* [N. Y.], **42**, 97–101 (1936).—Many parts can be rough-ground with heavy cuts and then finish-ground within a few ten thousandths of an inch on the same machine. C.B.J.

Finishing manganese steel parts by grinding. Fred B. Jacobs. *Iron Age*, **137** [11] 46–50 (1936). E.H.McC.

Grinding wheels and their uses: II, Grinding wheel manufacture. Johnson Heywood. *Abrasives*, **18** [2] 18–22, 39. **III, Theory of grinding.** *Ibid.*, [3] 26–29, 59–60. **IV, Selecting the right wheel for the job.** *Ibid.*, [4] 16–19, 58–62. **V, Wheel shapes and sizes.** *Ibid.*, [5] 16–19. **VI, Special grinding wheels.** *Ibid.*, [6] 20–21, 62. **VII, Segmental wheels—disk wheels—mounted wheels and points.** *Ibid.*, [7] 16–20. **VIII, Wheel truing and dressing tools.** *Ibid.*, [8] 17–20. **IX, Use of wheel dressing tools.** *Ibid.*, [9] 18–23, 62. **X, Tool and cutter sharpening.** *Ibid.*, [10] 28–33, 63–64 (1937).—This series of articles will be published in a book entitled "Grinding Wheels and Their Uses." For Part I see *Ceram. Abs.*, **16** [7] 193 (1937). F.J.Z.

Honing of cylinder bores. Koch. *Oberflächentech.*, **13** [16] 173–75 (1936).—Principles and developments of methods for finishing processes by honing are discussed; the modern process of honing combines a rotating motion with a reciprocating motion whereby the honing tool is pressed against the cylinder wall. The principal advantages are accuracy and speed. Ferrous alloys of any hardness can be honed with advantage, but nonferrous metal can not yet be honed successfully, as the honing stones clog and smear. Procedures, mechanical and automatic equipment, and cooling methods are described. M.H.

Industrial abrasives. Cartoux. *Usine*, **46** [24] 33 (1937).—C. reviews materials and methods of application. Materials, in order of increasing hardness, are garnet, emery,

corundum, silicon carbide, metal carbides, and diamond. Of the abrasives, 90% is extracted from Al; the principal artificial abrasives now in use are the carbides of Si, B, W, Co, Ta, and Ti. Mechanical and physical properties are given, and grinding disks and binders are discussed. M.H.

Keep down the cost of snagging and billet grinding. RALPH M. JOHNSON. *Iron Age*, **139** [15] 49–51 (1937). E.H.McC.

Macklin Company enlarges abrasive wheel plant. ANON. *Steel*, **98**, 90 (Jan. 27, 1936).—Expansion of plant facilities increased the floor space 50%; additional kilns and hydraulic presses were installed. Practically double the former volume of wheels is possible. Other equipment added is listed. H.E.S.

Manufacture of aluminum oxyhydrate from Kobakor bauxites by Boyer method in Uraluminum Works. L. A. BUGAREV, A. I. FONIM, AND L. M. LOSEV. *Legkie Metally*, **5** [2] 34–40 (1937); abstracted in *Chem. Zentr.*, **1937, ii**, 451. M.V.C.

Multirotary blasting table. AMERICAN FOUNDRY EQUIPMENT CO. *Steel*, **98**, 65 (March 23, 1936).—A multirotary blasting table is described and illustrated. H.E.S.

Quality of polished metal surfaces. F. GRÄSER. *Oberflächentech.*, **14** [17] 173–74 (1937).—G. explains how modern electron microscopy can be used to examine the nature of polished surfaces and discusses various views on whether or not the highly polished layer is formed of amorphous crystallites. Lees tried to etch the polished layer away and found that (in Au) the metal was not more amorphous in a depth of 27 to 45 Å or 2.7 to 4.5 $\times$ 10^{-7} cm. but clearly crystalline and that the crystallites are oriented in such manner that the same crystal surface is always pointing upward. The thickness of this oriented layer does not depend on the direction but on the method of polishing; while in soft Au the thickness is about 0.001 mm., it is much thinner in Cu. G. concludes that the polished "oriented" layer is originated by the pressure which is exerted in polishing vertically to the surface which causes the crystallites to "flow." The following processes probably take place during polishing of rotating disks: (1) removal of material by grinding (whereby polishing is equal to grinding with fine agents); (2) removal of protruding corners and edges from the crystal structure and formation of an amorphous layer; and (3) formation of a layer of small crystals oriented in direction of the surface brought about by pressure. This explains why polished surfaces are more corrosion-resistant than unpolished surfaces; the corrosive attack starts usually on crystal corners or edges, pores, cracks, etc., and polishing therefore reduces the possibility of attack. The amorphous layer has the same potential in all its parts and prevents the formation of local potential differences which lead to corrosion. M.H.

Sandpaper. D. H. KILLEFER. *Ind. Eng. Chem.*, **29** [8] 849–54 (1937).—K. describes the selection and processing of abrasive materials for use in the production of sandpaper. Illustrated. F.G.H.

Simplifying conversion of revolutions per minute into surface speeds. ANON. *Abrasives*, **18** [5] 13–15 (1937).—Revolutions per minute, surfaces speeds, and diameter of wheel form necessary data on grinding wheels to be used. By means of charts, the third item can be found where any two are known by drawing a straight line. F.J.Z.

Surface structure of silicon carbide. G. I. FINCH AND H. WILMAN. *Trans. Faraday Soc.*, **33** [2] 337–39 (1937).—Experiments showed that the electron diffraction halo pattern obtained from silicon carbide crystals is due to a superficial skin consisting in all probability of amorphous silica. Removal of the skin by abrasion or by quartz-etching reagents exposes the true silicon carbide crystal surface which then yields brilliant single crystal patterns. Such an amorphous layer formed in a Bunsen flame was sufficiently thin to be semitransparent to 50 kv. electrons, the crystal giving a composite halo-single crystal pattern. From this and the experimentally established fact that a monomolecular layer of $C_{22}H_{46}$ is not fully penetrated by electrons of this speed at grazing incidence, it was shown that the semitransparent amorphous film was less than 43 Å in thickness. G.R.S.

Test for relative sliding wear. DONALD S. CLARK AND ROBERT B. FREEMAN. *Metal Progress*, **31** [4] 399–401 (1937).—A new method for wear tests is given which measures the force required to produce a scratch in conjunction with the width of scratch made by a diamond of known dimensions. F.P.P.

Troubles due to grinding or machining. R. S. ARCHER, J. L. BURNS, AND V. BROWN. *Metal Progress*, **31** [6] 622–26 (1937).—Flaws and defects in metals, resulting from improper grinding practice, are described and illustrated. So-called inclusions are frequently nicks caused by careless handling. Grinding cracks, also the result of poor practice, are a heat effect. Finish grinding, even on a wet wheel, frequently induces "spotty hardness," as the surface may be heated above the critical range and quenched by the coolant whereas the inside of the stock is tempered by the heat of the grinding operation. "Hairline seams" may be the result of inclusions or nothing more than surface marking of a directional nature. Shop tests of machinability are often misleading, as differences in tool setup may produce as widely varying results as changes in the metal. F.P.P.

Wear resistance in relation to hardness. S. R. WILLIAMS. *Instruments*, **10** [5] 133–35 (1937).—W. discusses typical examples of abrasion and abrasive testing methods used on metals. *Ibid.*, [6] 161–62.—The theory of rate-of-wear difference is illustrated, wear tests on hard alloys are reviewed, and abrasive wheel hardness testers are described. F.P.P.

BOOK

Abrasive Handbook. B. KLEINSCHMIDT. **Vol. I, Grinding of Metals.** 368 pp., 457 figs., 3 tables. Price 16 Rm., bound 18 Rm. **Vol. II, Polishing of Metals.** 172 pp., 190 figs. and tables. Price 8.50 Rm., bound 10.50 Rm. **Vol. III, Grinding and Polishing of Wood.** 180 pp., 150 figs., 3 tables. Price 12 Rm. **Vol. IV, Grinding and Polishing of Glass, Stone, Leather, etc.** 180 pp., 160 figs. and tables. Price 12 Rm. Modern grinding and polishing methods are playing an important rôle in industry. An up-to-date and economical performance is hardly possible without the present highly developed polishing machines and processes of grinding.

That the quality of the working surfaces and the ac-

curacy thus obtained are superior to the values obtained by steel tools is especially evident in the manufacture of automobiles. A development in grinding and polishing similar to that in metal finishing may be recorded in the treatment of wood, stone, glass, leather, etc., by means of valuable and multiform grinding and polishing tools. Since the German abrasive industry is comparatively young and in view of the existing conditions, it has been difficult to assemble data for grinding and polishing means and present-day methods. The available book literature is small and covers only the treatment of special fields. A standard book, serving the whole field of application and rendering an all-embracing presentation of grinding and polishing tools and methods, exists only in the English language. K. treats fully, for the first time in the German language, the whole grinding and polishing technique, from abrasive raw materials to grinding and polishing machines. This book is to serve mainly the wide circle of users as a handbook for instruction of these timely methods. T. W. GARVE

PATENTS

Abrading apparatus. J. A. KEENAN (American Optical Co.). U. S. 2,095,503, Oct. 12, 1937 (Aug. 29, 1935).

Abrading machine. W. H. KASTENS. U. S. 2,094,843, Oct. 5, 1937 (Dec. 6, 1933; renewed Sept. 28, 1936).

Abrading tool. A. S. JOHNSON (United Shoe Machinery Corp.). U. S. 2,094,894, Oct. 5, 1937 (Dec. 11, 1931; July 11, 1935).

Apparatus for applying abrasive to polishing wheels, belts, etc. J. S. PORTER (D. & H. Scovil, Inc.). U. S. 2,098,306, Nov. 9, 1937 (March 17, 1937).

Apparatus for dressing abrading wheel. NORTON CO. Brit. 471,791, Sept. 22, 1937 (Feb. 6, 1935).

Apparatus for removing steam from grinders. F. W. PARTSCH (J. O. Ross Engineering Corp.). U. S. 2,093,478, Sept. 21, 1937 (Jan. 29, 1934). The combination in a pulp grinder of the type having a rotatable stone mounted on a horizontal axis located above a pool to run with its peripheral portion in the pool.

Article of self-bonded granular material and method of making. NORTON GRINDING WHEEL CO., LTD. Brit. 471,346, Sept. 15, 1937 (Sept. 30, 1935).

Attachment for use in centerless grinding, turning, etc. F. E. BULLOCK. Brit. 471,133, Sept. 8, 1937 (Feb. 29, 1936).

Balancing device for grinding or polishing wheels. JOHN ROCHE. U. S. 2,097,894, Nov. 2, 1937 (Sept. 26, 1935).

Buffing machine. G. E. MCLAUGHLIN AND W. E. BROUGHTON (Turner Tanning Machinery Co.). U. S. 2,094,999, Oct. 5, 1937 (June 5, 1936). U. S. 2,098,506, Nov. 9, 1937 (June 5, 1936; Jan. 12, 1937).

Buffing or polishing machine. C. O. JOHNSON (R. B. Waite). U. S. 2,095,501, Oct. 12, 1937 (May 27, 1936).

Calipering apparatus. R. A. COLE (Norton Co.). U. S. 2,097,784, Nov. 2, 1937 (May 21, 1936).

Cam grinding machine. NORTON CO. Brit. 473,963, Nov. 3, 1937 (March 27, 1935).

Drill grinding machine. R. C. WEISHAMPEL. U. S. 2,098,267, Nov. 9, 1937 (Feb. 18, 1935).

Grinder attachment. E. L. HUSSMANN. U. S. 2,098,147, Nov. 2, 1937 (July 16, 1936).

Grinder for slicer blades. C. W. JOHNSON (American Machine & Foundry Co.). U. S. 2,097,068, Oct. 26, 1937 (Nov. 9, 1934).

Grinding or abrading machine. NORTON CO. Brit. 473,094, Oct. 20, 1937 (July 12, 1935). W. W. TRIGGS (Norton Co.). Brit. 470,139, Aug. 25, 1937 (Sept. 19, 1936). Brit. 473,691, Nov. 3, 1937 (March 11, 1936).

Grinding or abrasive wheel. NORTON GRINDING WHEEL CO., LTD. (Norton Co.). Brit. 470,320, Aug. 25, 1937 (Dec. 15, 1936).

Grinding machine. H. L. BLOOD (Heald Machine Co.). U. S. 2,097,429, Nov. 2, 1937 (Jan. 13, 1937). L. G. CASEY (Cincinnati Electrical Tool Co.). U. S. 2,097,944, Nov. 2, 1937 (Feb. 1, 1937). A portable electric hand grinder is described. R. A. COLE (Norton Co.). U. S. 2,097,783, Nov. 2, 1937 (Oct. 9, 1935). An external cylindrical grinding machine is described.

Grinding machine for grinding noncircular shapes. EVERARD STUBBS (Norton Co.). U. S. 2,098,438, Nov. 9, 1937 (May 19, 1932).

Grinding machine and method of generating or correcting screw threads. A. SCRIVENER. Brit. 470,106, Aug. 25, 1937 (Feb. 14, 1936).

Grinding machine for reamers, etc. A. C. HOEH. U. S. 2,097,664, Nov. 2, 1937 (Oct. 26, 1931).

Grinding and polishing machine. G. D. MOOMAW (Crucible Steel Co. of America). U. S. 2,095,202, Oct. 5, 1937 (June 17, 1935).

Grinding screw threads in shouldered work. S. J. HARLEY. U. S. 2,098,145, Nov. 2, 1937 (Nov. 21, 1935).

Grinding wheel. H. O. ANDERSON (Norton Co.). U. S. 2,094,556, Sept. 28, 1937 (Oct. 25, 1935). The method of forming an abrasive body consists in providing open-mesh cloth, treating the cloth with an adhesive substance, depositing abrasive grain upon the cloth, matching sections of the cloth to form continuous cells, pressing, and setting the adhesive.

Grinding wheel. BAALIS SANFORD (Norton Co.). U. S. 2,097,803, Nov. 2, 1937 (Feb. 14, 1935). A thin, cutting-off grinding wheel comprises an outer annular abrasive zone of diamond grains and a reacted resinoid bond compacted and proportioned to provide a dense body and a central supporting zone of a granular filler other than diamond and reacted resinoid bond compacted into a rigid support for the outer zone, the granular filler and its bond in the inner zone being so proportioned that the bond occupies substantially the same volume percentage as does the bond of the abrasive zone.

Hydraulically operated lapping machine. NORTON CO. Brit. 470,217, Aug. 25, 1937 (Sept. 11, 1935).

Lapping machine. NORTON CO. Brit. 471,802, Sept. 22, 1937 (Feb. 6, 1935).

Machine for grinding, honing, or polishing razor blades. J. TREIBER. Brit. 470,151, Aug. 25, 1937 (Nov. 15, 1935).

Machine for producing or grinding hobs. MONARCH TOOL CO., LTD., AND H. WILSON. Brit. 473,964, Nov. 3, 1937 (March 21, 1936).

Machine for testing abrasive stones. JOSEPH SUNNEN. U. S. 2,093,650, Sept. 21, 1937 (June 4, 1934). A device for testing abrasive stones comprises a counter-abrasive, means for holding the stone in contact with the counter-

abrasive, means for imposing a definite pressure on the stone and the counter-abrasive, means for rotating the counter-abrasive, means for moving the stone across the rotating surface of the counter-abrasive, an abrasive element other than the stone in contact with the counter-abrasive, and means for lifting the stone out of contact with the counter-abrasive after a predetermined amount of relative movement between the stone and counter-abrasive.

Manufacture of sandpaper. W. J. TENNANT (Carborundum Co.). Brit. 473,619, Oct. 27, 1937 (April 16, 1936).

Method and apparatus for grinding. L. J. COONEY (Keystone Grinder & Mfg. Co.). U. S. 2,096,424, Oct. 19, 1937 (Feb. 26, 1935).

Method and apparatus for working material. A. J. BRUNNER (Western Electric Co., Inc.). U. S. 2,096,422, Oct. 19, 1937 (May 10, 1934). The method of grinding the cutting face of a tool in a plane which is parallel to the first plane and passes through the position occupied by the cutting point after the selected angular movement, and completing the grinding operation in the grinding plane by moving the tool about the fixed pivot during the grinding.

Method and machine for lapping a surface of revolution on a work piece. SHEFFIELD GAUGE CORP. Brit. 473,784, Nov. 3, 1937 (July 5, 1935).

Polishing article. C. E. WOODDELL (Carborundum Co.). U. S. 2,097,654, Nov. 2, 1937 (March 19, 1934).

Sanding block. C. C. ENGR. U. S. 2,095,495, Oct. 12, 1937 (March 7, 1936).

Saw-sharpening machines. J. B. TAUNTON. Brit. 472,230, Sept. 29, 1937 (March 16, 1936).

Sheet abrasive material and method of manufacturing. FRITZ SIMON (Norddeutsche Schleifmittel-Industrie, G.m.b.H.). U. S. 2,093,852, Sept. 21, 1937 (Dec. 20, 1934).

Stop mechanism for cylindrical grinding machines. J. LUND, LTD., AND J. S. SCAIFE. Brit. 473,693, Nov. 3, 1937 (March 16, 1936).

Surface grinder. ARTUDO DE MARCHI AND D. A. SANDIN. U. S. 2,097,655, Nov. 2, 1937 (Jan. 16, 1937).

Track grinding brick and adapter. THURE LARSSON (Norton Co.). U. S. 2,093,969, Sept. 21, 1937 (Aug. 9, 1935).

Two-slide automatic grinding machine. C. T. RAULE (Heald Machine Co.). U. S. 20,549, Nov. 9, 1937 (April 6, 1937); reissue of original 1,997,978, April 16, 1935.

Wheel-positioning mechanism for grinding or abrading machine. NORTON CO. Brit. 471,287, Sept. 15, 1937 (Aug. 15, 1935).

Art and Archeology

Etruscan art. ANON. *Amer. Mag. Art*, **30** [10] 628–31 (1937).—The recent acquisition, by the Metropolitan Museum, of three superb martial figures in terra cotta from the buried cities of Etruria has aroused great interest. The slow process of restoration of the terra cottas has given important data on the methods of the Etruscan sculptors. The three warriors or gods rank among the most magnificent ceramic achievements. They were built up by hand without molds or interior frames, painted before firing, and fired in one piece. The best preserved and largest figure is 8 ft. in height, and the head is more than three times life-size. Illustrated. M.E.C.

Finds at Chanhu-Daro. D. MACKAY. *Asia*, **37**, 501–505(1937).—Excavation in the Indus valley has given most of the information on pre-Aryan peoples in India. Recent work exposed the four uppermost layers at Chanhu-Daro. The lower two were of Harappa culture, closely similar to the previously excavated nearby city of Mohenjo-daro. Brick-covered drains were found along each side of the street. The inhabitants manufactured beads of pottery, carnelian, quartz, agate, and steatite and toys and figurines of pottery. The next layer showed pottery similar to that at Tell Halaf in northern Syria and the remains of a few brick houses. The topmost layer showed burnished gray pottery of crude make. W.D.F.

Finds at Tepe Gawra. E. A. SPEISER. *Sci. Amer.*, **157**, 133–36 (1937).—Recent excavations of levels 13 to 16 showed an advanced civilization in level 13, characterized by unusually graceful pottery artistically decorated with appropriate geometric designs, lapis, carnelian, and obsidian, and an architecture that in some respects was not equalled for thousands of years. Level 13 would be dated near the end of the fifth millenium B.C. In level 16 was found the earliest known closed pottery kiln with indirect firing, which was used in firing some of the earliest glazes found. W.D.F.

Modern stained glass windows. HENRI CLOUET. *Illustration* [Paris], No. 4892, p. 94 (1936).—C. records the Renaissance of stained glass; its treatment merely as pictures on glass, at the beginning of last century, was a profound mistake. In 1920, with the beginning of reparations after bombardments, there was a return to the robust creative methods of the Middle Ages. To recover this depth and beauty of color, pot glass is used almost exclusively. Through the efforts of Labouret and Decormont, a range of colors unknown to the workers of the Middle Ages has been obtained. Labouret's technique is far from traditional. He "sculptures" thick slabs of glass to obtain facets that reflect the rich colors; the slabs are held together by cement. M.E.C.

Potter's art in Sicily. T. ZAMBRINI. *Corriere Ceram.*, **18** [7] 221–23 (1937).—Potters' wheels used in Sicily do not differ much from those used in remote antiquity, as can be proved by ancient murals. The workmen are skilful and turn out ware of curious and varied form with great rapidity. The furnaces require the greatest care; those used for crockery are cylindrical and $^1/_3$ buried in the ground; those used for earthen pots are conical and divided into 3 horizontal parts with apertures for the flames to pass through. A typical representation of the traditional potter's art of Sicily is the figure of a woman carrying a vessel of water on her head. M.V.C.

BOOKLET

History of faience. Egyptian tile of 3000 years ago. ANON. Monograph, Metropolitan Museum of Art, New York. Abstracted in *Brit. Clayworker*, **46** [545] xxii-xxiii (between pp. 184 and 185) (1937). R.A.H.

PATENTS

Decalcomania. FRANK HART. U. S. 2,094,886, Oct. 5, 1937 (Sept. 1, 1936).

Decalcomania paper. LEWIS DAVIS. Can. 365,470, April 20, 1937 (April 17, 1935; in U. S., May 31, 1934).—A decalcomania paper comprises a suitable backing sheet, a water-resistant coating of a resinous nature to take a decalcomania printing, the coating being resistant to the common solvents used in printing inks, and a protective coating of water-resistant material bonding the resinous coating and the backing sheet, the coating being substantially insoluble in a solvent which readily dissolves the protective coating. G.M.H.

Decalcomania paper. LEWIS DAVIS (MacLaurin-Jones Co.). Can. 365,471, April 20, 1937 (April 17, 1935; in U. S., Aug. 23, 1934). A decalcomania paper comprises a suitable backing sheet, an outer waterproof coating to take decalcomania printing, and a protective coating of a rubbery nature between the waterproof coating and the sheet. G.M.H.

Designs for:

Ashtray. A. I. LORENZEN (Owens-Illinois Glass Co.). U. S. 106,670, Oct. 26, 1937 (Aug. 31, 1937). J. E. SPENCE (Hazel-Atlas Glass Co.). U. S. 106,872, Nov. 9, 1937 (Aug. 18, 1937).

Bookend. W. E. MACKELFRESH, JR. (Owens-Illinois Glass Co.). U. S. 106,691, Oct. 26, 1937 (Sept. 22, 1937).

Bottle. A. L. KEY (Hazel-Atlas Glass Co.). U. S. 106,138, Sept. 21, 1937 (July 9, 1937). W. R. LEACH, JR. (Carr-Lowrey Glass Co.). U. S. 106,628, Oct. 19, 1937 (Sept. 16, 1937).

Bowl. J. E. SPENCE (Hazel-Atlas Glass Co.). U. S. 106,456, Oct. 12, 1937 (Aug. 18, 1937).

Canister. M. H. CONNOR (Owens-Illinois Can Co.). U. S. 106,109, Sept. 21, 1937 (Feb. 1, 1937).

Combined butter and almond tub. C. B. ILGENFRITZ AND E. E. SLICK, JR. (United States Glass Co.). U. S. 106,794, Nov. 2, 1937 (June 22, 1937).

Deep bowl. C. B. ILGENFRITZ AND E. E. SLICK, JR. (United States Glass Co.). U. S. 106,795, Nov. 2, 1937 (June 22, 1937).

Hollow double-wall glass reflector. C. E. ANDERSON AND C. R. PALMER. U. S. 106,877, Nov. 9, 1937 (Aug. 28, 1935).

Jar. IVOR CORDY (Hazel-Atlas Glass Co.). U. S. 106,814, Nov. 2, 1937 (Sept. 16, 1937). FRASIER SMITH (Hazel-Atlas Glass Co.). U. S. 106,153, Sept. 21, 1937 (July 8, 1937).

Milk pitcher. C. B. ILGENFRITZ AND E. E. SLICK, JR. (United States Glass Co.). U. S. 106,792, Nov. 2, 1937 (June 22, 1937).

Nappy. C. B. ILGENFRITZ AND E. E. SLICK, JR. (United States Glass Co.). U. S. 106,796, Nov. 2, 1937 (June 22, 1937).

Oval relish tray. C. B. ILGENFRITZ AND E. E. SLICK, JR. (United States Glass Co.). U. S. 106,797, Nov. 2, 1937 (June 22, 1937).

Plate. YUKIO BUMA (Morimura Bros., Inc.). U. S. 106,879, Nov. 9, 1937 (March 4, 1937). W. T. JOHNSON (Mayer China Co.). U. S. 106,773, Nov. 2, 1937 (Aug. 28, 1937). JOHN WADSWORTH (Mintons, Ltd.). U. S. 106,160, Sept. 21, 1937 (June 4, 1937). GEORGE WESP (Continental Ceramics Corp.). U. S. 106,699, Oct. 26, 1937 (Aug. 14, 1937). J. H. WILSON (Jackson Vitrified China Co., Inc.). U. S. 106,554, Oct. 19, 1937 (Sept. 1, 1937).

Range. RUDOLPH HOFFMAN (American Stove Co.). U. S. 106,868, Nov. 9, 1937 (July 26, 1937).

Sugar bowl. C. B. ILGENFRITZ AND E. E. SLICK, JR. (United States Glass Co.). U. S. 106,791, Nov. 2, 1937 (June 22, 1937).

Tumbler. C. B. ILGENFRITZ AND E. E. SLICK, JR. (United States Glass Co.). U. S. 106,793, Nov. 2, 1937 (June 22, 1937).

Ornamenting ceramic articles. W. C. HERAEUS G.M.B.H. Ger. 647,355, July 3, 1937; Cl. 80b. 23.07; *Chem. Abs.*, **31**, 6842 (1937).—A ceramic article is coated with a suspension of a ceramic pigment in a liquid, and before this coating has dried a suspension of the same pigment in another liquid, or of another pigment in the same or a different liquid, is applied irregularly to the article, *e.g.*, by spraying or brushing. The article is then fired. Marbled or crackled effects are obtained. Examples are given.

Ornamenting ceramic articles. REINHOLD SCHLEGELMILCH PORZELLANFABRIK. Ger. 647,354, July 2, 1937; Cl. 80b. 23.06; *Chem. Abs.*, **31**, 6842 (1937).—A plastic glaze is applied to ceramic articles, and a design is traced in the glaze with a stylus or like tool. The glaze is then fired.

Cements

Acidproof cement is quick setting. SAUER-EISEN CEMENTS CO. *Steel*, **98**, 66 (May 25, 1936).—A self-hardening, quick-setting, sodium silicate cement, known as No. 31, is especially adaptable to bricklaying in connection with linings for pickling tanks, towers, fillers, vats, pipe, and receivers. Initial set occurs within 1 hr. after mixing, and the final set, within 36 hr. Chemical action of the cement causes the set rather than drying. Tests have shown a tensile strength of 365 lb./sq. in. increased to 400 lb./sq. in. by the addition of 50% silica sand. The cement is resistant to all acids (except hydrofluoric), oil, fire, water, and solvents. H.E.S.

Calculation of raw materials for cement. V. N. YUNG. *Tsement*, **3** [8] 4–18 (1935).—Y. supposes that solid dicalcium silicate dissolves in the fused liquid and that when it is in a highly concentrated solution in the melt of free, supposedly molecularly dispersed lime, it forms tricalcium silicate (alite) which isolates in the interval of the clinkering temperature in the form of finest crystals. The free-lime content in freshly formed clinker must not surpass 2% if it is necessary to clinker the mixture with high grades of saturation, which in most cases ensures the constancy of volume of fresh high-grade cement. When the addition of large amounts of iron oxides to the raw-material mixture reduces the aluminate modulus to 0.64 or less, no tricalcium aluminate will be contained in celite. When the modulus

is equal to 0.64, only brownmillerite is formed; when it is less than 0.64, dicalcium ferrite is formed simultaneously. In both cases this is a cement of the so-called ore Portland cement type; the coefficients in the formula for calculations must be changed accordingly. Brownmillerite consists of $2CaO \cdot Al_2O_3$ and $2CaO \cdot Fe_2O_3$. It follows that for this case the coefficient 1.1 is to be taken for alumina and 0.7 for iron oxide. For silica it remains the same, 2.8. The saturation of clinker with lime, therefore, must be expressed by the following full formula with the following coefficients for Portland cement of the usual chemical composition: $10(CaO - CaO_{free} - O + SO_3) \div 2.8\ (SiO_2 - SiO_{2\,insoluble} + 1.65Al_2O_3 + 0.35Fe_2O_3)$. P.B. & E.S.

Controlling heat of hydration of cements. P. H. Bates. *Cement & Lime Manuf.*, **10** [6] 162–64 (1937).—Cements of low heats of hydration are produced by (1) reduction of alumina and lime content, accompanied by a large increase of iron oxide and a smaller increase of silica or by large increase in silica and reduction in amounts of the other major oxides, (2) heat treating the clinker, and (3) partial hydration of normal cements. G.R.S.

Effect of mineralizers on synthesis of aluminates and aluminoferrites of calcium. N. A. Toropov and T. M. Dyuko. *Vsesoyuznyĭ Nauchno-Issled. Inst. Tsementov Bull.*, No. 2, pp. 3–9 (1937).—The systems of (1) calcium monoaluminate, $CaO \cdot Al_2O_3$, (2) brownmillerite, $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$, and (3) $5CaO \cdot 3Al_2O_3$ were studied. The batches were composed of CaO, alumina, and iron oxide to which boric ore was added. The mixtures were heated to various temperatures. The results are tabulated. Curves show the speed of formation of these mineral clinkers. M.V.C.

Manufacture of Portland cement (mechanical processes). J. H. Billson. *Foundry Trade Jour.*, **54** [1023] 245–48, 249 (1936).—Portland cement manufacture in a modern plant is described. The use of refractories and the pulverizing of coal for direct firing are discussed. Illustrated. H.E.S.

Obtaining gypsum sponge from anhydrite. A. B. Gecelev. *Stroitel. Materialy*, **1937**, No. 6, pp. 38–40.—The formation of pores is obtained by the addition to gypsum calcined at 600° to 700° of dolomite dust and sulfuric or hydrochloric acid (2% of the weight of the gypsum); this addition leads to the formation of carbon dioxide. Samples were obtained in the laboratory with a volume weight of 0.5 to 0.9. The crushing strength in 28 days attains 75 to 100 kg./cm.^{2}. P.B. & E.S.

Plaster molds of high tensile strength. Anon. *Ind. Chemist*, **12** [140] 428 (1936).—Additions of starch, dextrin, gum arabic, glue, and ground marshmallow root increase the toughness of plaster molds. They also slow down the setting-rate so that working to shape may more conveniently be carried out. A little alum contained in the water used for mixing the plaster hardens it but hastens the setting time. Fine asbestos flour is also added to increase abrasion resistance. Depending upon the purpose for which they are intended, plaster molds can often be preserved by filling the pores with paraffin wax applied from solution, an oil such as olive oil, or resin applied as a spirit varnish. H.E.S.

Research on pozzuolana. N. Parravano and V. Caglioti. *Ricerca Sci.* [2] **8**, I [7–8] 271–86 (1937).—The authors show that, given the conditions of formation, pozzuolanas should contain, near the crystalline constituents, a vitreous phase originating during the consolidation of primitive magma. The vitreous phase has physical and chemical properties analogous to those of a gel heated to high temperature; this is proved by comparison of the absorption velocity of lime, aside from various hydrogels and alcolgels of pure silica and silica with aluminum and iron oxide, and from the quantity of heat which is developed during absorption. The microscopic and röntgenographic analyses and considerations of a geochemical nature indicate that the origin of the active constituents of pozzuolana is due to pulverization of the fused magma caused by gaseous substances developing in the eruptive process. The authors confirmed their views by preparing aërogels of silica alone and silica with iron oxide and aluminum oxide and pointing out the analogy of the behavior of these with that of pozzuolana. M.V.C.

Technical properties of quick and hydrated lime. G. Malquori. *Ricerca Sci.* [2] **8**, I [11–12] 531–32 (1937).—Results found by Wells, Bishop, and Watstein (*Ceram. Abs.*, **16** [3] 82 (1937)) agreed with the observations of Malquori and Giannone (*Ricerca Sci.* [2] **7**, I [7–8] 265–75; II [7–8] 383–90 (1936); [2] **8**, I [3–4] 113–16 (1937)). These tests, begun by M., have been continued in other directions, and the behavior of magnesia lime in pozzuolana mortar is discussed. M.V.C.

BOOK AND BULLETIN

Pozzuolanic Cements. Edited by V. I. Aksenov, A. A. Baikov, V. A. Kind, L. S. Kogan, S. M. Royak, and G. M. Ruschuk. Vsesoyuznogo Nauchno-Issledovatel'skogo Instituta Tsementov, Leningrad, 1936. 599 pp. **Theory of hardening of lime-pozzuolana cements.** V. N. Yung. Pp. 377–94. Reactions occurring between hydrates of lime and various modifications of SiO_2 and the products obtained are described. The hardening of calcareous pozzuolana bonds takes place very slowly and only in the presence of moisture. Because of interreaction between hydrates of lime and amorphous silica, adsorption systems of indefinite composition are found at first, followed by amorphous jelly-like hydrosilicates of the general type $xCaO \cdot ySiO_2 \cdot nH_2O$. In sand-lime (siliceous) brick, crystalline hydrosilicates intimately connected with quartz grains are formed; with carbonization they change into crystalline particles of carbonate (calcite) without lowering the strength of the brick. The hardening of lime-slag cement (basic blast-furnace slag) begins with the changing of slag into a colloidal form under the effect of the hydrate of lime. M.V.C.

Relative value of gypsum and anhydrite as additions to Portland cement. Paul S. Roller and Murray Halwer. *U. S. Bur. Mines Tech. Paper*, No. 578, 15 pp. Supt. of Documents, Govt. Printing Office, Washington, D. C. Price 5¢. Questions as to the importance of anhydrite as an addition to Portland cement and the amount that may be tolerated in gypsum are answered. R.A.H.

PATENT

Process and apparatus for forming cement clinker. H. S. Lee. U. S. 2,095,446, Oct. 12, 1937 (Aug. 29, 1935).

Enamel

Accurate timing has increased the scope of spot welding. PAUL G. WEILLER. *Machinery* [N. Y.] **42**, 655–56 (1936).—Important variables in spot welding are power, pressure, time, and the electrodes. Spot welds of dependable strength can be made on a variety of metals without marring the surface by controlling the actual welding time to between one-sixtieth and one-thirtieth of a second. C.B.J.

Acid cleaning of sheet steels. RICHARD SAXTON. *Sheet Metal Ind.*, **10** [107] 211–12 (1936).—S. discusses the use of acid baths in cleaning carbon steel and stainless steel sheets. In cleaning carbon sheets both HCl and H_2SO_4 are employed. HCl can be used cold at atmospheric temperature. The H_2SO_4 bath is cheaper, gives higher output from an equal volume of solution, and has an immersion time of approximately 6 min. against 24 min. in HCl bath. With cold HCl the most economical solution is one part of commercial acid to two parts, by volume, of water. Though many favor the working of this bath until spent minus additions, actual process conditions prove that addition of acid as required is the more economical method both in output and time essential for performance of the process. A 6% sulfuric acid bath at about 90°C gives a high output though it is possible to employ efficiently as low as 2% solution if the temperature and immersion time allowance be proportionately increased. Acid cleaning of stainless sheets necessitates the use of a sulfuric bath for approximately 30 min. at 60°C and a 15 to 20% nitric solution employed cold for approximately 7 min. An alternative method, more economic but more risky, is a single bath made up of 25% HCl and 5% nitric acid employed in the cold state. As descaling of surfaces prior to operation is essential, S. suggests a suitable descaling liquor as follows: HCl 50%, HNO_3 5%, water 50%, inhibitor 0.25% (by volume). Immersion of material in boiling water immediately following its withdrawal from new baths of HCl solution is recommended as the best method of eliminating or neutralizing occluded hydrogen which induces acid rust. A.P.S.

Advantages of the electric furnace for firing enamel and its present perfection. S. HERBST. *Elektrowärme*, **7** [10] 209–17 (1937).—H. claims improved qualities, greater economy, and increased safety in operation. Different types of furnaces for enameling bathtubs, sinks, sheets, etc., are described. M.H.

Alkalis in pickle room cleaning. D. J. BENOLIEL. *Amer. Enameler*, **10** [6] 10 (1937).—B. gives valuable notes on the use of alkalis in the pickle room. J.N.H.

Application of enamel coats by spraying method. KHVASS. *Litelnoe Delo*, **7**, 38–41 (1936); abstracted in *Chem. Zentr.*, **1937**, ii, 835.—K. reviews the present manufacture of glass enamel coats, their application and characteristics, spraying apparatus, and working conditions. M.V.C.

Barium, a ceramic material. M. DE BOUCCAR. *Argile*, No. 174, pp. 3–5 (1937).—Barium carbonate, whose melting point is about 1350°, is an excellent flux for enamels, producing great luster even for enamels poor in silica. Up to 7% barium carbonate can be used in enamels poor in alkalis and up to 15% in enamels containing B_2O_3. Ba is found in nature mostly as $BaCO_3$ and $BaSO_4$. The oxide is obtained by calcination. BaO is a basic oxide. Barytine is used to obtain iridescent effects. M.V.C.

Batch-type enameling furnaces. F. S. MARKERT. *Ind. Heating*, **4** [8] 640–41 (1937).—M. gives operating data of a few installations where the gas-radiant tube furnace has been successfully employed. M.H.

Black specks in cover-coat enamels. JAMES D. TETRICK. *Amer. Enameler*, **10** [4] 8, 22 (1937).—T. traces the origin of black specks, discussing, as sources, the mill room, spraying operations, shop conditions, furnace conditions, and the ground coat. J.N.H.

Cast-iron die castings. C. O. HERB. *Machinery* [N. Y.] **42**, 569–74 (May, 1936).—Die casting has been limited to nonferrous metals because of the high melting temperatures of iron and steel. Cast-iron die blocks fitted with simple liners of cold-rolled steel that are shaped to suit the contour of the pieces to be cast are used. These liners are relatively inexpensive and can be provided in quantities for replacement. A pressure of 20 lb./sq. in. is used. The structure of the castings is close-grained and uniform. The tensile strength is materially increased. Surfaces are smooth and require no tumbling. Die construction, control of melting, and the die-casting procedure are described. C.B.J.

Cast-iron leadless enamels. J. K. HOSSACK. *Jour. Can. Ceram. Soc.*, **6**, 82–84 (1937).—The greatest difficulty encountered in the development of cast-iron leadless enamels is to obtain an enamel for application directly on the iron with good adherence, workability, gloss, and opacity. Research carried out to obtain a suitable substitute for litharge has been unsuccessful, although considerable advancement has been made. White or light-colored enamels, therefore, can not be used directly on cast iron. Five classes of leadless enamels are listed. These are distinguishable by their refractory qualities. Leadless enamels are advantageous in that less enamel is required; better whites and cleaner and truer colors are obtained; and the enamels have a harder, more durable finish and are more resistant to thermal shock. Leadless enamels are discussed with reference to ground coats, milling, spraying, drying, and firing. J.G.P.

Chipping. ANON. *Amer. Enameler*, **10** [7] 14 (1937).—Well-established safeguards against chipping are reviewed. J.N.H.

Cleaning developments—sodium orthosilicate—sodium cyanide. F. E. P. GRIGGS. *Jour. Can. Ceram. Soc.*, **6**, 84–88 (1937).—G. discusses sodium orthosilicate as a new base for alkali cleaners and sodium cyanide as a neutralizing medium after acid pickling. The industrial removal of oil and grease from fabricated shapes, prior to the application of critical finishes, is dependent upon (1) saponification and (2) emulsification. Most greases used in metal fabrication are acidic in nature or mixtures of acidic greases with inert mineral oils. Solutions of sodium orthosilicate would have a more rapid dissolving action on acidic grease than any of the other alkalis considered, with the exception of caustic soda. Sodium orthosilicate, while not having the high resistance of caustic soda, has a much longer life. Emulsification is the dispersion of the grease into minute globules which can be carried by the solution. J.G.P.

Composition of enamel batches. VIELHABER. *Emailwaren-Ind.*, **14** [22] 157–58 (1937).—V. criticizes an article by Schütz (*Giessereipraxis*, No. 33–34 (1936)) which discusses an enamel batch containing 19.19% tin oxide in the finished enamel. At present not more than 4 to 6% tin oxide is used in enamel batches. Numerous compositions of enamel batches are now discussed in ceramic periodicals and they are no longer secret. M.V.C.

Crazing and flaking of majolica fireplaces. FERD. KELLER. *Glashütte*, **67** [11] 190–91 (1937).—Crazing of majolica enamel is caused by tensions present in the enamel coat. The chief properties which influence tensions are thermal expansion and elasticity of the metal which is to be enameled and of the enamel to be applied. Thermal conductivity is of great importance when the enameled article is subjected to severe changes of temperature as in fireplaces. Flaking of the enamel is due chiefly to inadequate or defective working of the cast iron. M.V.C.

"Dairy bar" finished in porcelain enamel. CINCINNATI MFG. CO. *Steel*, **98**, 57 (Feb. 17, 1936).—Exterior and interior walls are covered with black and white porcelain enameled panels applied with frameless steel clip-strip. Metallic and porcelain enameled effects are carried out in interior fixtures and decorations. H.E.S.

De-enameling. ANON. *Amer. Enameler*, **10** [5] 16–17 (1937).—A safe method of de-enameling and care to be taken for re-enameling ware are described. Questions on black specks, neutralizer bath, sulfide of iron in the pickle tank, and the limit of iron in a sulfuric pickling solution are answered. J.N.H.

Design of metal parts for porcelain enameling. M. C. COUTTS. *Jour. Can. Ceram. Soc.*, **6**, 78–82 (1937).—Porcelain enameled products should be designed so that (1) they have "sales appeal," (2) no unusual difficulties will be experienced during the enameling process, and (3) assembly is facilitated, strains are eliminated, and shipping hazards are reduced to a minimum. C. deals with the last two requirements. See *Ceram. Abs.*, **16** [2] 58 (1937). J.G.P.

Direct-fired heater and exhaust fan removes vapor from pickling room. DRAVO-DOYLE CO. *Steel*, **98**, 61 (June 22, 1936). H.E.S.

Enameled iron wash fountains. BRADLEY WASHFOUNTAIN CO. *Steel*, **98**, 64 (Feb. 17, 1936).—Enameled, pressed-iron wash fountains up to 36-in. diameter circular and 54-in. diameter semicircular units are now available. The bowls are solid one-piece pressings finished in acid-resisting vitreous enamel and have a roll rim or a deep apron. They are fabricated from high quality deep drawing annealed stock, No. 10 gage for the semicircular units and No. 11 gage for the 36-in. circular, and are reinforced with special annular and semiannular disks. H.E.S.

Enamels on cast iron. L. FAURE. *Usine*, **46** [20] 27 (1937).—F. discusses principles and required properties of enamel and cast Fe to obtain firm adhesion. The piece should be heated below 950°C to avoid decomposition of the cementite, whereby graphite, which does not adhere to the metal and to which enamel does not adhere, is precipitated. The enamel should fuse below this temperature, therefore, and the pieces should be left in the furnace for as short a time as possible. Heating and cooling should be gradual. The expansion coefficients of cast Fe and the enamel should be as similar as possible; figures are given for a number of materials and for mechanical resistance. M.H.

Enamel-shop troubles during 1936 in Canada. R. A. ATKINSON. *Jour. Can. Ceram. Soc.*, **6**, 74–75 (1937).—A. discusses (1) blistering of certain castings when the second coat is fired, (2) hairlines in sheet-iron parts such as hi-shelves, (3) drawing troubles, (4) variation of ivory colors, and (5) chipping of enamel in the field. J.G.P.

Enamelware: food regulation. ANON. *Food*, **6** [70] 377 (1937).—In Bulgaria, glazed or enameled metal or earthenware vessels intended to contain food must not yield any lead or zinc when boiled in a 4% vinegar solution for one-half hour. H.H.S.

Fishscales in black enamels. VIELHABER. *Emailwaren-Ind.*, **14** [15–16] 115 (1937).—Black sheet enamels are especially sensitive to formations of fishscales. These enamels are usually composed of an easily melting batch which is melted with oxides coloring dark, such as iron, manganese (pyrolusite), copper, nickel, or cobalt oxides; clay and black pigments are then added and the whole is ground together. The formation of fishscales is greatly reduced when the black pigments are melted and not added to the mill. Decreasing the amount of metallic oxides, especially iron and copper oxides, also considerably lowers the formation of fishscales. Pyrolusite has no effect on their formation. M.V.C.

Glass-coated steel in food industry. ANON. *Australian Food Manuf.*, **7** [2] 23 (1937).—Glass-enameled steel has been used by food manufacturers for 25 years and is becoming increasingly popular. Its use is recommended because it does not contaminate the food being processed, it can be heated and cooled to extreme temperatures, it is easily cleaned and readily sterilized, and it does not harbor spores. H.H.S.

Ground coat. ANON. *Amer. Enameler*, **10** [4] 18 (1937).—An analysis of up-to-date methods of avoiding difficulties in the cleaner tank is presented. J.N.H.

Heating furnace economy and operations. M. H. MAWHINNEY. *Metal Progress*, **28** [4] 32–34, 38 (1935).—Several practical considerations relative to furnace operation are discussed. M. gives tables showing the energy liberated in various types of furnaces (including enameling furnaces) in heating one unit of work, comparative costs of several fuels and electricity, and the time required to "heat up" cold furnaces, according to their size, to various temperatures. Practical operating pointers are included. F.P.P.

Identification of nonmetallic inclusions in steel. R. GRAHAM AND R. HAY. *Jour. Roy. Tech. Coll.* [Glasgow], **4** (Part 1), 77–84 (1937).—Use of polarized light, variety of etching reagents, and microchemical methods in a new method for identifying Fe, Mn, Si, Al, and Cu inclusions are discussed. W.H.B.

Improved cabinet design reduces enamel chipping. C. S. PEARCE. *Steel*, **98**, 40, 43 (April 20, 1936).—P. presents a new method of constructing a cabinet for mechanical refrigerators, in which the parts of the cabinet are welded together and enameled as a single piece. H.E.S.

Iron-cobalt system. J. H. ANDREW AND C. G. NICHOLSON. *Iron & Steel Inst., Alloy Steels Research Committee,*

First Report, pp. 93–96 (1936).—Ingots weighing 100 g. were melted in Alundum crucibles in an atmosphere of cracked ammonia. Cooling curves were made, using a tungsten-molybdenum thermocouple. There is a peritectic transformation at 1505°C between a saturated delta phase containing 15% cobalt and liquid containing 27% cobalt with the formation of a gamma phase containing 25% cobalt. The solidus and liquidus lines are too close together to permit their accurate determination. The solidus has a minimum at about 1475°C and 50% cobalt. Between 1000° and 1400°C, iron and cobalt form a continuous series of gamma solid solutions. The transformations in the solid were determined by thermal analysis. The temperature of the alpha-gamma transformation is raised slightly with increasing concentration of cobalt, reaches a maximum at about 950°C and 50% cobalt, and then falls very sharply. At temperatures of 500°C and below, the alpha-gamma range extends between 74 and 82% cobalt. J.B.A.

Large screen in porcelain enamel on steel. R. B. AITKEN. *Steel*, **98**, 43 (June 1, 1936).—Weighing 400 lb. and measuring 9 ft. high and 12 ft. wide, the "Warrior Screen," depicting an African devil dance, is one of the largests projects ever completed in porcelain enamel. H.E.S.

Method of studying inclusions in alloy steels. W. A. HARE AND GILBERT SOLER. *Metals & Alloys*, **8** [6] 169–72 (1937).—The authors describe a method in which the analysis and mineralogical nature of the inclusions are determined by chemical and petrographic means, supplemented by X-ray studies, if necessary. Results with several types of alloy steels are given, with photomicrographs of two typical inculsions. F.P.P.

Modern vertical core ovens. C. A. MAUCH. *Iron Age*, **140** [1] 26–28 (1937).—An oven designed for firing 320 cores per hour is described. E.H.McC.

Operating results of an enameling furnace. O. SEIDLER. *Elektrowärme*, **7** [10] 218–19 (1937).—S. describes operating energy and distribution of losses of a furnace for 300 kg. small parts per hour. M.H.

Porcelain enameling unit to fire 6- x 12-foot sheets. INGRAM-RICHARDSON MFG. CO. *Steel*, **98**, 47 (April 20, 1936). H.E.S.

Prizer-Painter Stove Works. ANON. *Amer. Enameler*, **10** [4] 12–13 (1937).—A brief sketch is given of the history and development of the Prizer-Painter Stove Works, Reading, Pa. J.N.H.

Radiant tubes for vitreous enameling. S. M. STOLER. *Amer. Enameler*, **10** [5] 5–6 (1937).—S. outlines advantages and discusses problems pertaining to this comparatively new type of furnace. J.N.H.

Removing scratches. RICHARD CARNO. *Amer. Enameler*, **10** [5] 9 (1937).—C. describes a method developed at the O'Keefe and Merritt Co. for reclaiming scratched or marred porcelain enameled ware. J.N.H.

Sand- and shot-blasting. J. H. D. BRADSHAW. *Foundry Trade Jour.*, **54** [1021] 205–208 (1936).—Sandblasting has developed into a great labor-saving industry which provides a finish entirely unobtainable by any other method and which, for some purposes, is absolutely essential. Sandblasting will remove scale, rust, etc., and will produce a surface particularly suitable for painting, lacquering, and enameling. The enamel will adhere with greater tenacity, and a more uniform covering is obtained. Fused sand and embedded particles are removed from the surface, thereby preventing damage to tools in the machine shop. Dust from cores, etc., is readily removed, and it is less costly and more convenient than the old-fashioned pickling process. Chilled-steel abrasives can successfully replace sand or quartz. **Discussion.** TUCKER *et al.* *Ibid.*, [1028] 341–42. H.E.S.

Sheet-metal base for bathtubs competes with cast iron. BENNETT CHAPPLE. *Metal Progress*, **29** [2] 47–48 (1936).—A special quality of Armco iron has been developed as a basis for enameled lavatory wear in place of cast iron. Details of application of ground and finish coats are given. The corrugated bottom possible with sheet-iron tubs is claimed to be an important safety advantage. F.P.P.

Shrinkage distortion in welding. Review of literature to January 1, 1937. W. SPRAGEN AND G. E. CLAUSSEN. *Welding Jour.* [N. Y.] **16** [7] Supp. 29–39 (1937).—The authors give a complete survey of a subject of vital importance to designers and fabricators of welded structures. 83 references. W.H.B.

Steel bathtubs. ANON. *Steel*, **98**, 19–20 (June 15, 1936).—The advantages and disadvantages of the pressed-steel and cast-iron bathtubs and plumbing fixtures are compared. H.E.S.

Technical development in enamel operation. H. J. KARMAUS. *Emailwaren-Ind.*, **14** [18] 131–34; [19–20] 139–42; [21] 151–52; [23–24] 169–72; [25] 178–80; [26] 186 (1937).—K. deals with the latest raw materials, devices, methods, and compositions in the enamel industry and the new uses of enameled ware. Patent literature in this field is also discussed. M.V.C.

Tension and notched-bar tests on an alloy steel. J. MUIR. *Jour. Roy. Tech. Coll.* [Glasgow], **4** (Part 1), 1–11 (1937).—M. investigates fractured Ni-Mo steel crank web by means of various heat treatments and the resulting mechanical properties obtained with a Hounsfield tensometer. The material was 0.32% C, 0.41% Ni, 0.23% Si, 1.60% Mn, 0.44% Mo, 0.024% S, 0.041% P. Attention is directed to the value of yield point strain in the tensile tests as being possibly a more important value than yield point stress in that it would show the metals' capacity for transferring the load at some overstressed region to other regions. Doubt is cast on the wisdom of using steels in quenched and tempered conditions, since the drastic oil quench may have instituted hairline cracks in the metal interior and thus weakened it for service. See *Ceram. Abs.*, **16** [3] 95 (1937). W.H.B.

Wastes of enamels. W. F. FINDLAY. *Jour. Can. Ceram. Soc.*, **6**, 75–78 (1937).—F. discusses the waste that occurs in the milling, storing, setting-up, spraying, and dipping of enamels in the enameling plant and gives the following suggestions: (1) Mill-room waste may be reduced by (*a*) repeating the kind of enamels milled, (*b*) handling the enamel as little as possible between the milling and its application, (*c*) thinning the enamel as nearly as possible to the consistency at which it is used, and (*d*) using smooth-surfaced screens, stirring paddles, and containers made from corrosion-resistant metal or enameled steel. (2) Waste in spraying may be reduced by (*a*) use of large enamel containers such as the pressure type, (*b*) use of low velocities with correct baffling in the spray booth, (*c*) simple

design of work rests, turntables, etc., and (*d*) regulation of air pressure and experimentation with the angle at which the enamel is applied. (3) In dipping, wastes may be reduced by (*a*) use of hooks instead of standards on which the ware is to be drained, and (*b*) reclaiming of ground-coat enamel when washing down tanks, work rests, and drainboards. The parts should be designed so that brushing is unnecessary. J.G.P.

Welding gray iron castings. WILHELM HERMANN. *Welding Ind.*, **5** [4] 124–27 (1937).—H. cites the field of application as (1) removal or repair of typical casting faults such as local surface shrinkages, pipes, pores, cutting out of large inclusions, and filling up; (2) correcting the geometrical imperfections of castings; (3) repairing cracked castings as far as possible in view of the nature of the castings and type of subsequent application; (4) uniting separately poured sections of castings so as to form a complete unit; and (5) modifying or improving surface properties, such as local edge hardness, etc., by adding iron compositions and uniting them with a coating by welding. Cold welding of gray Fe should be used only where the more satisfactory hot or semihot welding can not be applied. W.H.B.

White ground coat. HANS MELZER. *Glashütte*, **67** [19] 300–301 (1937).—Numerous attempts to produce a white or weakly colored ground enamel have been unsuccessful. By replacing cobalt and nickel oxides with antimonates or trivalent antimony (up to 7%), white enamel granules were obtained which produced irregular and unsatisfactory coats after grinding and firing and whose adherence and resistance were low. Sometimes a so-called "white" coat is used which in reality is gray-green. The addition of white pigments to ground coats has been unsuccessful. Antimony derivatives have little resistance to heat and coat irregularly. Gas opacification can not be applied to ground enamel. Cerium oxide, however, proved to be satisfactory. It is refractory and produces a ground enamel of light color. The usual amounts of cobalt and nickel oxides are used, and 3 to 3.5% of cerium oxide is added to the mill. It should be ground separately with clay and water and then added. This grinding is necessary because the effect of cerium oxide depends on its fineness. Cerium has only one degree of oxidation, it is resistant to acids, and does not lower the brightness of the enamel. M.V.C.

STANDARD AND BOOKLET

Colors for kitchen accessories. ANON. *Nat. Bur. Standards, Com. Standard, CS*62-38, Sept. 16, 1937. 8 pp. Free. See *Ceram. Abs.*, **16** [6] 167 (1937). R.A.H.

Production of castings for porcelain enameling. PORCELAIN ENAMEL INSTITUTE, 612 North Michigan Ave., Chicago, 1937. 11 pp., 15 figs. Price 10¢. The booklet is the result of coöperation between expert foundrymen and representatives of the porcelain enameling industry. It is divided into easily understood sections including blistering, warping, influence of design, influence of molding practice, influence of melting and pouring, influence of iron composition, and influence of raw materials.

PATENTS

Acid-resisting vitreous enamels. R. D. COOKE (Rundle Mfg. Co.). U. S. 2,096,030, Oct. 19, 1937 (June 25, 1936). A vitreous enamel suspension includes water which is saturated with carbon dioxide.

Apparatus for smelting. G. H. MCINTYRE AND R. W. STUART (Ferro Enamel Corp.). U. S. 2,097,378 and 2,097-379, Oct. 26, 1937 (May 11, 1937).

Enamel frit. IGNAZ KREIDL. Can. 369,549, Oct. 26, 1937 (Jan. 30, 1937). G.M.H.

Method and agent for removing enamel from enameled articles. I. G. FARBENINDUSTRIE A.-G. Brit. 473,556, Oct. 27, 1937 (April 13, 1935).

Glass

Age of glass. U. GUALTIERI. *Oesterr. Glaserztg.*, **2**, 105–106 (1937). J.F.H.

Analysis of colored glasses: I, Determination of copper. W. GEILMANN AND O. MEYER-HOISSEN. *Glastech. Ber.*, **15** [3] 105–108 (1937).—The iodometric process of de Haen or the modification by Bruhns is recommended. This process and modification are fully described and illustrated with examples. Interference of other glass ingredients, especially that of iron, is discussed. G.R.S.

Appearance of weathered glass. ANON. *Sprechsaal*, **70** [17] 223 (1937).—Tests with a lime-soda-silicate glass which was artificially weathered showed that the appearance of the glass does not yield any clues as to the duration and intensity of corrosion. Illustrated. M.V.C.

Applications for light-polarizing glass. LAND-WHEELWRIGHT LABORATORIES, INC. *Steel*, **98**, 48 (Feb. 17, 1936).—The glass, called Polaroid, makes use of a synthetic organic crystal which absorbs practically all of the visible light in one of its plane polarized components and transmits a large proportion of the other component. The glass is a suspension of these minute artificial crystals in a cellulose matrix. Known applications for the glass include removal of glare from automobile headlights; commercial projection of life-like, three-dimensional movies; strain testing of engineering structures; theatrical color illumination; one-way vision window glass; colorless sun glasses; and improved illumination for oil paintings. See *Ceram. Abs.*, **16** [5] 147 (1937). H.E.S.

Behavior of glasses under treatment by the blow-lamp flame. M. THOMAS. *Jour. Soc. Glass Tech.*, **20** [80] 152–69 (1936).—T. describes tests which indicate that roughening or corrugation is due to surface impoverishment of alkali. The effect occurs more readily with increased Al_2O_3 or decreased alkali content. "Halo" formation is described and assumed to be a phenomenon inverse to the roughening effect. Foam formation occurring with high softening-point boric oxide glasses is ascribed to B_2O_3 evaporation. Bubble formation in glasses of the SiO_2–Al_2O_3–CaO–BaO system can not yet be explained. Blackening and clouding are briefly discussed. 19 references. C.J.P.

Black glass from peat slag. N. S. BREGMAN. *Keram. & Steklo*, **13** [8] 28–32 (1937).—Peat slag from the gas generating plant of the Gomel glassworks can be used for the production of black glass of the marbleite type. Slag batch composed of slag and small admixtures of quartz is easily

melted and pressed. Any type of inexpensive articles, especially face tile, may be cast or pressed from this type of glass. M.V.C.

Boring holes in glass. G. Schieb. *Oesterr. Glaserztg.*, **1**, 7–10 (1936). J.F.H.

Breaking strength of glass. Effect of flaws and scratches. A. J. Holland and W. E. S. Turner. *Jour. Soc. Glass Tech.*, **20** [80] 279–302 (1936).—An extensive study was made of the effect of various factors on the transverse strength of flat drawn sheet glass 0.260 to 0.285 cm. thick, 10 cm. long, and 0.8 cm. wide. The authors considered the influence of (1) condition of the cutting tool, (2) mechanically grinding and polishing sides and edges, (3) fire-polishing sides and edges, and (4) scratches. For otherwise similar specimens, the breaking strengths varied from 570 kg./cm.^{2} (new diamond cut edges in tension) to 1056 kg./cm.^{2} (fire-polished sides and edges). An attempt was made to correlate the depth of penetration of residual edge flaws with the observed strengths. The evidence suggested that a scratch 0.001 mm. or more in width was needed to cause appreciable reduction in strength. C.J.P.

Chemical composition of glasses suitable for the manufacture of window glass by the automatic drawing process. K. Kamita, H. Yamamoto, M. Matsuo, H. Yagai, and H. Ota. *Jour. Soc. Glass Tech.*, **20** [80] 170–80 (1936).—The rate of melting and refining, chemical durability, viscosity, softening point, and devitrification temperature were measured for a series of glasses based on the formula SiO_2 72%, Al_2O_3 1.5%, Na_2O 14%, (CaO + MgO) 12%. By changing the CaO:MgO ratio, a point was found near MgO = 3.5% where results were most favorable. Data are presented in tables and curves. C.J.P.

Chief points in the separate stages of glass manufacture. Anon. *Glashütte*, **67** [23] 373–75 (1937).—Over 120 points are compiled regarding the most important questions relating to (1) batch, (2) melting, (3) purification and homogenizing, (4) removal, (5) shaping, (6) annealing, (7) working, (8) packing, (9) storing and transportation, and (10) use and consumption. M.V.C.

Coloration of glass by staining: III. P. Gilard and L. Dubrul. *Jour. Soc. Glass Tech.*, **20** [80] 225–44 (1936).—The tint and intensity of silver-stained glasses were measured by the colorimetric method. Color formation proceeded by progressive absorption of blue and then green, red being transmitted almost completely. Secondary components have a preponderating influence on the staining capacity. In contrast, the principal components govern the capacity for copper staining. For Parts **I–II** see *Ceram. Abs.*, **12** [10–11] 363 (1933); **13** [2] 28; [3] 52 (1934). C.J.P.

Comparison between standard method and more rapid methods for the analysis of simple glasses. J. D. Cauwood and Violet Dimbleby. *Jour. Soc. Glass Tech.*, **20** [81] 338–44 (1936).—Commercial soda-lime-silica glasses were analyzed in two laboratories by (1) the standard method involving fusion by sodium carbonate, and (2) a more rapid method embodying decomposition by hydrofluoric and sulfuric acids. The same analytical procedure was employed in both cases for the determination of bases other than alkalis. The comparison was extended to glasses containing both CaO and MgO. Provided the HF decomposition was conducted with care, there was no appreciable difference in the results for Al_2O_3 and CaO by use of the two methods. C.J.P.

Crushing and sieving of glass to insure control of the surface of the grains. Edwin Berger. *Jour. Soc. Glass Tech.*, **20** [81] 384–404 (1936).—A statistical consideration of average grain volume and average surface per unit volume is presented. Both are determined by mesh size and form factors. B. considers a number of effects, including the crushing process, kind and duration of sieving, average mesh size, and grain friction. C.J.P.

Decolorizing glass. F. C. Flint. *Jour. Soc. Glass Tech.*, **20** [81] 358–74 (1936).—F. claims that in any definition of "color" the following factors must be considered: (1) kind of light, (2) surface of the glass and its reflectivity, (3) index of refraction and dispersion, (4) selective absorption of color by the glass, (5) physiological effect on the eye, and (6) the psychology involved. He discusses each of these briefly, together with the difficulty of obtaining glass free from iron, state of oxidation of the iron, permissible limits of iron content, and the principal decolorizers now employed. It is claimed that the effect of these auxiliary chemicals is understood and that the industry is settling down to a well-regulated knowledge of the subject. See *Bull. Amer. Ceram. Soc.*, **16** [6] 236–46 (1937). C.J.P.

Decolorizing of glass—a review. E. J. Gooding. *Jour. Soc. Glass Tech.*, **20** [81] 375–83 (1936).—G. reviews the published data concerning the decolorizing of glass, dealing in particular with selenium decolorizing and the effects of introducing certain minor constituents such as arsenious oxide, nitrates, and sodium sulfate. 103 references. C.J.P.

Defects appearing during the working of glass. Friedrich Mergler. *Glashütte*, **67** [16] 259–60; [17] 276–79 (1937).—Defects which may appear in glassware during painting, enameling, pressing, and the making of mirrors are analyzed. The most common reason for their appearance is insufficient cleaning of the glassware before working, which results in poor adherence. Defective hoods for fumes in the muffles, irregular enamel coats, and impure raw materials are the chief sources of defects, and suggestions are given for their elimination. M.V.C.

Determination of iron in glass. N. E. Densem. *Jour. Soc. Glass Tech.*, **20** [81] 303–14 (1936).—D. gives the results of a systematic investigation of the equilibrium between ferrous and ferric iron in glass. Colorimetric, gravimetric, volumetric-oxidation, electrometric, and volumetric-reduction methods for the determination of the total iron content are described. For the determination of ferrous oxide, a modification of J. H. Pratt's hydrofluoric acid method is found to be the most reliable. Only in the absence of arsenic and closely allied constituents are the results dependable. C.J.P.

Determination of small quantities of iron oxide in raw materials and glass. A. Dietzel. *Jour. Soc. Glass Tech.*, **20** [81] 315–18 (1936).—Titrimetric methods for the analysis of iron are described. D. recommends that ferrous iron be determined with cerium sulfate or potassium permanganate and ferric iron with titanous chloride. The possibilities of spectral analysis of iron are mentioned. C.J.P.

Equipment and technique for making mirrors. A. LAURENT. *Oesterr. Glaserztg.*, **1**, 47–50, 77–78 (1936). J.F.H.

Experiment station for glass. ANTONIO TOMMASELLI. *Centro Studi Ceram.*, **2** [9–12] 97–98 (1935).—The establishment of a national experiment station for the study of glass in Italy, similar to European and American institutions, is essential for (1) the systematic study of indigenous raw materials with the purpose of utilizing them more extensively and decreasing dependence on foreign markets, and (2) the pursuance of research on technical problems of the glass industry. M.V.C.

Feldspar in glass. EGON ARNOT. *Sprechsaal*, **70** [29] 374 (1937).—Alumina improves glass, especially with respect to water and acid resistance and fluctuations of temperature. The simplest method of introducing alumina into glass is to add feldspar to the batch. The addition of feldspar requires a corresponding change in the composition of the batch. The advantages and properties of feldspar are analyzed. For hard glasses, high additions of alumina are usually introduced in the form of a mixture of hydrate of alumina and feldspar in the ratio of 10 to 1. M.V.C.

Formation of glass gall. ANON. *Glashütte*, **67** [24] 390–92 (1937).—Glass gall is not a typical characteristic of sulfate glasses or of glasses melted defectively in pots as is often assumed. It appears in tank melts even in batches which contain no sulfate. It is an alkaline earth-alkali sulfate and may be formed from the batch or after melting. The conditions of the formation of glass gall are discussed. M.V.C.

Glass air filters. OWENS-ILLINOIS GLASS CO. *Steel*, **98**, 72 (March 30, 1936). H.E.S.

Glass for false teeth. FRANK LOTT. *Science News Letter*, **30** [814] 311 (1936).—L. gives the progress in the use of glass as a base for false teeth. The prime advantage of the glass base is its more natural color which matches satisfactorily the gum tissues of the majority of patients; the color is lasting. The glass is strong enough to stand considerable pressure as in chewing. When it does break from being dropped, a disadvantage which may be overcome by shatterproofing, it is easily repaired.

Glass fiber. ANON. *Eng. Mining Jour.*, **138** [9] 42, 44 (1937); see *Ceram. Abs.*, **16** [2] 59 (1937). J.L.G.

Glass surfaces in optical contact. RAYLEIGH. *Proc. Roy. Soc.* [London] **A156**, 326–49 (1936).—The method of getting glass or silica plates into optical contact is discussed together with the behavior of scratches in hindering contact. A method is given for determining the mechanical work done in separating two contacted glasses. This amounts to about 70 ergs/sq. cm., about half being recoverable on recontacting. The reflection from the interface between two contacted wedges of glass or silica varied in different specimens from 5×10^{-4} to 5×10^{-3}, based on reflection from a single detached surface in the open as unity. The reflecting power is not affected by applying pressure. The black center of Newton's rings between a large radius lens and a flat plate shows a residual reflection which varies in different specimens. It behaves in all respects like the interface of glasses in adhesive contact, and the absence of adhesion is explained by the forces restoring the flattened spherical surface after release of outside pressure. A.P.

Heat-resisting glass. G. SCHIEB. *Oesterr. Glaserztg.*, **1**, 68–71 (1936).—The household use of Durax glass manufactured by the Jena Glass Works is described and illustrated. J.F.H.

Influence of loading velocity and form of loading curve on values of the strength of hollow glassware. K. H. BORCHARD. *Glastech. Ber.*, **15** [3] 99–105 (1937).—The results of the measurements of strengths of hollow glassware are dependent on the research methods employed. To these research methods also belongs the form of the weight-time curve, made from the loading of the test piece. The possibility was studied of developing a method of obtaining the agreement of two strength values which were taken from different loading curves by recalculation from a normal loading curve. From previous studies, the relation of the strength to permanent loading is known to be a rectangular curve. In order to estimate the corresponding relation on a triangular loading curve (increasing pressure with constant loading speed up to the point of rupture), new studies were undertaken. The results of the relation are expressed in the following equation: $F = F_B \left(\frac{92}{100} - \frac{8}{100} \cdot \log z\right)$, where F_B = breaking strength in atm. at a permanent loading of 5 sec. and z = loading time to the point of rupture in min. These relations are also shown in diagrams. 20 references. See "Causes—," *Ceram. Abs.*, **14** [7] 158 (1935). G.R.S.

Influence of thermal history of glass on composition and workability. LUDWIG SPRINGER. Translated in *Ceram. Ind.*, **26** [2] 122–23; [3] 186–88 (1936); see *Ceram. Abs.*, **15** [11] 331 (1936). E.J.V.

Instrument for controlling the decoloration of glass. L. DEMKINA. *Tech. Phys. U.S.S.R.*, **4** [5] 380–82 (1937).—An instrument which represents a combination of a photometer and a wedge colorimeter is described. It provides a means of determining the necessary concentration of color reducers to ensure maximum transparency. C.J.P.

Intensification of glassmelting processes. I. I. KITAĬGORODSKIĬ. *Jour. Soc. Glass Tech.*, **20** [80] 188–99 (1936).—Different methods of batch charging are discussed, and the importance of particle size of the batch is stressed. Feeding in heaps is criticized and is claimed to decrease the rate of refining, lower the glass quality, and cause decreased furnace efficiency. Feeding the batch in thin layers is claimed to increase the refining rate, utilize the heat input most efficiently, and aid glass quality. This theory was tested with considerable success in several large-scale experiments. See *Ceram. Abs.*, **15** [10] 298 (1936). C.J.P.

Italy; land of prototypes for glass application. G. SCHIEB. *Oesterr. Glaserztg.*, **2**, 101–104 (1937).—Architectural applications, including all-glass doors, are illustrated. J.F.H.

Kinetics of the coloring of glass by X-rays. C. E. NURNBERGER AND R. LIVINGSTON. *Jour. Phys. Chem.*, **41** [5] 691 (1937).—A new experimental study of the kinetics of the coloring of glass by X-rays is presented. A kinetic interpretation consistent with the new results but retaining the essentials of a former theory (*Ceram. Abs.*, **15** [1] 14 (1936)) is stated. It is suggested that a modification of

Przibram's theory (*Sitzber. Akad. Wiss. Wien, Abt. IIa*, **135**, 197 (1926)) on the coloring of rocksalt by β-rays might be adjusted to fit the present data. C.J.P.

Making glass mirrors. OTTO HERFURTH. *Diamant*, **58** [35] 413 (1936); **59** [1] 6; [2] 18; [3] 30; [5] 49–50; [8] 80–81; [9] 89–90 (1937).—The preparation of silvering solutions according to the methods of Kaiser and Lumière is described; the latter's method is much simpler but uses a greater amount of silver. The working temperature is very important. In hollow-glass works, each type of ware should be tested to determine the best working conditions and methods; extreme cleanliness is essential. Recuperation is performed by precipitating AgCl, and reduction, by means of zinc or caustic soda and sugar. The silvered glass must be protected, preferably by coppering or by protective lacquer. See "Silver—," *Ceram. Abs.*, **16** [3] 88 (1937). M.V.C.

Manufacture of watch glasses. ANON. *Oesterr. Glaserztg.*, **1**, 28–31 (1936).—Refractory blocks for shaping varied forms are discussed. J.F.H.

Maximum amount of cullet in glass batch. S. YA. RAF. *Keram. & Steklo*, **13** [7] 23–27 (1937).—The variation in the quantity of cullet introduced, the method of introducing it, and the state in which it is used do not change the coefficient of expansion and softening temperature of glasses. Variations in the indexes found are within the limits of permissible errors which could have occurred during the experiments. Changes in the cullet content of glasses, method of introduction, and state of the cullet have no marked effect on the chemical resistances of the glasses. There is practically no change in viscosity of glasses with variation of the cullet content, method of introduction, and its state at the same temperatures (1250°, 1150°, 1050°, 950°, and 850°C). The percentage content of alkalis in the glass and the softening temperature of this glass are in inverse proportion, *i.e.*, with a lowering of the alkali content, the softening temperature increases. Glass in which granulated cullet and cullet in lumps are mixed with the batch melts more rapidly than that in which the cullet is introduced separately. M.V.C.

Measurement on the adsorption of oxygen on glass at liquid oxygen temperatures. A. VAN ITTERBEEK AND W. VAN DINGENEN. *Physica*, **4** [8] 631–38 (1937).—The results of oxygen adsorption measurements on glass at 90.0°K and 67.3°K and at pressures between 10^{-1} mm. and 1.0 mm. can be represented by a formula of the type $X^2 = k_1k_2p/(1 + k_2p)$, where X is adsorbed quantity per cm^2., p is the pressure, and k_1 and k_2 are constants. The constant k_2 is independent of the temperature. Similar expressions were found by Zeise and by Keesom and Schmidt (*Ceram. Abs.*, **13** [10] 252 (1934)), but for X^3 at liquid hydrogen temperatures and for X^4 at liquid helium temperatures. C.J.P.

Melting glass 846 with Inderskil borates. I. K. ANDRZHIEVSKII. *Keram. & Steklo*, **13** [7] 12–15 (1937).—The composition and properties of large deposits of borates which represent complexes of calcareous, magnesium calcareous, magnesium, and calcareous soda borates are described. The chief minerals are of the following compositions: $2MgO \cdot B_2O_3 \cdot H_2O$, $2CaO \cdot 3B_2O_3 \cdot H_2O$, $Na_2O \cdot 2CaO \cdot 5B_2O_3 \cdot 16H_2O$, $CaO \cdot MgO \cdot 3B_2O_3 \cdot 6H_2O$, and $4CaO \cdot B_2O_3 \cdot 15H_2O$. The chemical composition of glass 846 is 74.0 SiO_2, 3.0 B_2O_3, 3.0 Al_2O_3, 6.0 CaO, 4.0 MgO, and 10.0 Na_2O. The results of experiments show that (1) Inderskil borates are suitable for melting glass 846; (2) they can replace boric acid, and the glass obtained is of high quality; and (3) the melting and purifying of this glass proceeds more easily with borates. M.V.C.

Metallurgical needs of the glass industry: I. R. D. SMITH. *Metals & Alloys*, **7** [9] 217–20; [10] 263–67 (1936); see *Ceram. Abs.*, **16** [9] 272 (1937). G.M.P.

Possibilities in glass-concrete constructions. G. SCHIEB. *Oesterr. Glaserztg.*, **1**, 4–7 (1936); see "Translucid—," *Ceram. Abs.*, **16** [11] 335 (1937). J.F.H.

Present-day glass decoration by engraving, etching, and sandblasting. J. DRAHONOVSKY. *Jour. Soc. Glass Tech.*, **20** [80] 218–24 (1936).—D. gives a brief, general review of the subject. Illustrated. C.J.P.

Principles underlying the chemical corrosion of glass. EDWIN BERGER. *Jour. Soc. Glass Tech.*, **20** [80] 257–78 (1936).—An analysis of work done at Jena on chemical durability is given. The following conclusions are drawn: (1) the test method should be chosen to permit measurement of attacks of short duration; (2) water, acid, and alkali attack must be distinguished; (3) for a given temperature and reactive liquid, two values on the time curve must be established; (4) the liquid must be thoroughly stirred; and (5) the surface area must be known. C.J.P.

Properties of "multicellular" glasses. BERNARD LONG. *Jour. Soc. Glass Tech.*, **20** [80] 181–87 (1936); see *Ceram. Abs.*, **16** [3] 88 (1937). C.J.P.

Public lighting engineers. C. I. WINSTONE *et al.* Presented at Conference of Assn. of Public-Lighting Engineers; *Electrician*, **119** [12] 308–11 (1937).—The 400-watt, luminescent, mercury-cadmium discharge lamp is discussed. The outer glass bulb is internally coated with the luminescent powder. The initial efficiency with the powder is 37 lumens per watt while the red ratio is 5 to 6% as compared with 1% for the normal high-intensity mercury-vapor lamp. The light from the lamp appears more green or yellow-green than that from the mercury lamp. H.K.R.

Raman effect in glasses. R. LANGENBERG. *Ann. Physik*, **28** [1] 104–13 (1937).—L. observed Raman spectra for SiO_2, B_2O_3, and 24 glasses of various compositions. In the range characteristic of the glasses, the following frequencies were observed and ascribed: SO_4 ion, about 500, 625, 800, and 1000 to 1140 $cm.^{-1}$; BO_3 ion, about 700, 915, and 1445 $cm.^{-1}$. Two frequencies not classified in the foregoing were observed with molten B_2O_3, *viz.*, at 803 and 1261 $cm.^{-1}$. The presence of Pb, Ba, and the alkali metals, appeared to have no effect on the Raman spectra of the glasses studied. F.P.P.

Refraction of tempered plate glass. J. J. HOPFIELD. *Jour. Optical Soc. Amer.*, **26**, 24–25 (1936).—The refractive index of heat-strengthened plate glass was found to diminish considerably from surface to center. As a consequence, (1) prisms of such glass form spectral lines that are greatly curved, and (2) plates of glass with plane parallel ends refract like cylindrical, concave lenses. The direction of the change indicates that strain rather than evaporation of the more volatile constituents from the surface is responsible. Further theories that have not been tested are (1) that a "Prince Rupert drop" should have a greater focal length than an annealed drop of the same size, (2) that an approxi-

mately spherical concave lens could be made from a normal plane parallel segment of a round cylindrical rod of tempered glass, and (3) that in "annealed" plate and sheet glass a slight stratification of refractive index should be observable; this stratification could be used in studying the large strains in tempered flat glass. A.P.

Refractive-index changes in optical glass occasioned by chilling and tempering. F. TWYMAN AND F. SIMEON. *Jour. Optical Soc. Amer.*, **26**, 121 (1936).—Hopfield and Watkins do not give quantitative figures on the effect which they have observed. Attention is called to a paper by the writers (*Ceram. Abs.*, **3** [2] 36 (1924)) examining the effect in detail. A.P.

Report of progress on glass durability methods. W. C. TAYLOR. *Jour. Soc. Glass Tech.*, **20** [81] 405–15 (1936).—T. reviews the work of a special committee of the Glass Division of the American Ceramic Society on a powder method designated as A.C.S. No. 1 and on comparative results by the Sheffield method. Twenty-one laboratories participated in the work. The results indicated that the A.C.S. No.1 method is convenient for comparing simple bottle and sheet glasses. It does not appear suitable for comparing these glasses with others or for comparison between other types of glasses. This method, using a dilute alkali instead of a dilute acid extraction, seemed to give a reliable indication of the general durability of six glasses. The acceleration due to temperature and pressure differed for each glass. A test to ascertain the tendency to fogging is described. C.J.P.

Securit glass. R. LHOTE. *Mécanique*, **20**, 209–13 (1936); abstracted in *Chem. Zentr.*, **1936, i**, 1506. M.V.C.

Significance of secondary glassforming materials in glassmelting. ZSCHACKE. *Glashütte*, **67** [23] 371–72 (1937).—By secondary glassforming materials, Z. specifies those constituents of the batch which are added to it in relatively small amounts and which influence the melting and purifying of glass. Purifying and decolorizing materials do not belong to this group, although the boundary between these two types of materials is not easy to define. This is also true of secondary and main glassforming materials because a part of the former may appear as chief glassforming agents in certain types of glasses; these materials will then have a very different effect than when added in small amounts to the batch. The difficulty of determining the effect of secondary glassforming material is pointed out. Natural secondary glassforming materials, such as water, zinc oxide, feldspar, hydrate of alumina, Na_2SiF_6, fluorspar, and glass frits (artificial secondary glassforming materials), are discussed. M.V.C.

Special glasses in the lighting field. R. SCHMIDT. *Glastech. Ber.*, **15** [3] 98–99 (1937).—S. gives a report of the development and present status of special glasses transmitting and absorbing ultra-violet light. Fluorescent glasses, metal vapor-coated glasses, and high softening-temperature glasses are included. Further purification of raw materials, especially elimination of iron and titanium, is unlikely from an economical viewpoint. Tubing having interior coatings of finely divided crystalline materials (sulfides and selenides) is competing with uranium glasses because of strong uniform fluorescence effects. The development of glasses resistant to metallic vapors is connected with the development of discharge lamps. The chief difficulties are the poor working properties and corrosion during melting. High softening-point glasses are of more importance in connection with high-pressure discharge lamps. The tendency in glass compositions is toward more Al_2O_3 and alkaline earths and little or no alkalis. The attainment of proper expansion, good working properties, and freedom from devitrification presents difficulties. Tables of characteristic glass compositions are given. 74 references. G.R.S.

Spun glass for insulation of railway equipment. NORDMANN. *Chem. Fabrik*, **10**, 299–300 (1937); *Chem. Abs.*, **31**, 6762 (1937).—The method of applying the insulation to locomotives and steam lines is described. Comparative tests on passenger locomotives, uninsulated, insulated by the usual air space, and insulated with 50 mm. of mineral wool, at 60 to 80 km./hr., showed that air insulation reduced the loss to about 50% of that of the uninsulated engine, and the mineral wool saved 40 to 43% more than the air; sufficient data are not yet available.

Structure of glass. A. GANGULI. *Z. Krist.*, **97**, 88–90 (1937).—G. enumerates the usual conditions favoring glass formation and suggests that application of very high pressure may not only break large crystals into very small ones but may even lead to breakdown of the lattice itself, perhaps because of interpenetration of atoms; thus the crystal may be reduced to a jelly-like mass. H.I.

Surface layer of polished silica and glass with further studies on optical contact. RAYLEIGH. *Proc. Roy. Soc.* [London], **A160**, 507–26 (1937).—The reflecting power of a polished silica surface examined in a liquid having the same refractive index as the body of the material varies widely according to treatment. Surfaces polished by a process which removes material rapidly or surfaces washed in dilute hydrofluoric acid do not reflect appreciably. Surfaces polished by methods which do not remove material quickly may reflect as much as 0.28% of the incident light. The surface's refractive index may increase from 1.461 to as much as 1.6. These effects are found in a lesser degree in ordinary glass and in a much lesser degree in crystal quartz. The thickness of the modified layer was measured as 0.06λ. The variable reflecting power formerly found (see "Glass surfaces—," this issue) from the interface of two silica or glass surfaces in optical contact is now explained and controllable. The mean distance between two crystals of quartz in optical contact is about seven times the spacing of the layers of silicon atoms within the crystals. A.P.

Surface tensions in sodium lead silica glasses. A. A. APPEN. *Optiko-Mekh. Prom.*, **6** [12] 17–18 (1936); abstracted in *Chem. Zentr.*, **1937, ii**, 1872.—Surface tensions in the Na_2O–PbO–SiO_2 systems are not additive as in the binary systems Na_2O–SiO_2 and PbO–SiO_2. Surface tensions decrease with increasing lead content. Humidity and the presence of N_2, O_2, and CO_2 in the air have no effect. See *Ceram. Abs.*, **16** [8] 242 (1937). M.V.C.

Surface working of flat glass by grinding: I. OTTO HERFURTH. *Diamant*, **59** [10] 99–100; [12] 119–20; [13] 129–30; [14] 145–46; [15] 154–55; [16] 164–65; [17] 173–74 (1937).—A detailed discussion is given of methods and apparatus. M.V.C.

Thermal conductivity of glass, chilled glass, quartz, fused quartz (transparent), coal, isolite, porcelain, etc. SHIRO NUKIYAMA. *Trans. Soc. Mech. Engrs.* [Japan], **2** [8] 344–45 (1936); abstracted in *Physik. Ber.*, **18** [14] 1286 (1937).—The measurement of the heat conductivity by a relative comparison method is described; the same heat flow flows successively through the comparison plate with known heat conductivity (glass plate) and the plate to be determined in the range 0° to 100°C. M.H.

Universal apparatus for working glass. G. SCHIEB. *Oesterr. Glaserztg.*, **1**, 72–74 (1936).—The apparatus consists of a small hand electric drill with the appropriate tools for engraving, cutting, boring, and polishing. J.F.H.

Use of thin deposits of aluminium on glass as heating elements. B. LONG. *Rev. Aluminium*, **14** [92] 753–56 (1937); abstracted in *Bull. Brit. Non-Ferrous Metals Research Assn.*, No. 101, p. 8 (1937).—The production and use of thin deposits of aluminium for such purposes as (glass) screen heaters, (glass) floor heaters, etc., are discussed.

Valuation of raw materials for the fused rock industry. A. S. GINZBERG. *Trudy Petrograf. Inst. Akad. Nauk S.S.S.R.*, **6** 415–24 (1934); abstracted in *Chem. Zentr.*, **1937, ii,** 1063.—Russia does not possess basic basalts with 42 to 44% SiO_2; therefore the suitability of other rock, such as diabase, andesite-basalt, porphyry, trap rock, etc., was studied. Siberian trap rock is more or less similar to French and German basalts. Materials with a high acid oxide content were found unsuitable, *e.g.*, volynite with 53.8 SiO_2, 2.6 TiO_2, and 13.48% Al_2O_3. M.V.C.

BOOK

Glass Tank Furnaces (Le Four à Bassin). R. W. DEVILLERS AND F. E. VAEREWYCK. Translated from the French and edited by S. R. Scholes. Ogden-Watney Publishers, Inc., 11 West 42nd St., New York, 1937. Lithoprinted, 139 pp., 108 figs. Price $3.50. This book is partly for the glass technologist but even more it is a book of practical usefulness for the factory man. It tells him, in simple language and in familiar terms of measurement, what is being done in the most modern plants. All aspects of glass tanks are treated fully. The figures in the original book have been reproduced as well as an entended bibliography and a French-English-German glossary of glass furnace terms. To these, the American edition has appended conversion tables to afford ready comparison of English and metric units and Fahrenheit and Centigrade temperatures; data have been converted into the foot-pound system, and extended comment on American practice has been added. For a review of the original book see *Ceram. Abs.*, **15** [4] 120 (1936).

PATENTS

Apparatus for:

Drawing glass strip. PILKINGTON BROS., LTD., AND A. JOLLIE. Brit. 472,172, Sept. 29, 1937 (March 17, 1936).

Feeding glass. H. M. BLACK (McKee Glass Co.). U. S. 2,096,780, Oct. 26, 1937 (March 12, 1935).

Feeding molten glass. T. F. PEARSON. Brit. 473,271, Oct. 20, 1937 (Feb. 7, 1936).

Forming hollow glass articles. THOMAS WAUGH, JR. (Hartford-Empire Co.). U. S. 2,095,896, Oct. 12, 1937 (March 20, 1936).

Making hollow glassware with an ornamented surface. VERRERIES-GOBELETERIES L'ESPÉRANCE, SOC. ANON. Ger. 646,563, June 17, 1937; Cl. 32*a*. 8; *Chem. Abs.*, **31**, 6841 (1937).

Tempering glass. LIBBEY-OWENS-FORD GLASS CO. Brit. 472,516, Oct. 6, 1937 (Dec. 26, 1935).

Bottle or glassblowing machine. W. E. EVANS (O'Neill European Machine Co.). Brit. 470,326, Aug. 25, 1937 (Nov. 9, 1935).

Corrugated glass roof. E. H. HOBBIE (Mississippi Glass Co.). U. S. 2,093,559, Sept. 21, 1937 (April 27, 1936).

Corrugated glass sheets and their manufacture. J. M. J. C. VOSCH. Brit. 473,165, Oct. 20, 1937 (Nov. 5, 1935).

Double glazing. GAMES SLAYTER (Owens-Illinois Glass Co.). U. S. 2,094,381, Sept. 28, 1937 (June 6, 1932; renewed Aug. 13, 1936).

Double window construction. E. F. TONEY (Pittsburgh Plate Glass Co.). U. S. 2,094,435, Sept. 28, 1937 (Sept. 6, 1935).

Etching glass. GENERAL ELECTRIC CO., LTD., AND A. C. GEFFKINS. Brit. 470,413, Aug. 25, 1937 (Feb. 14, 1936).

Feeding molten glass. T. F. PEARSON AND H. A. ROBSON. Brit. 470,253, Aug. 25, 1937 (Feb. 7, 1936).

Glass bottle manufacturing machine. F. W. ARMYTAGE. Can. 369,146, Oct. 5, 1937 (Nov. 10, 1936). G.M.H.

Glass composition for electrical discharge devices HELLMUTH FISCHER. U. S. 2,097,275, Oct. 26, 1937 (Feb. 21, 1934). An electrical discharge device has a wall of glass that includes in its composition a luminescence-affording compound of a metal selected from a group that consists of lead, uranium, vanadium, copper, tin, antimony, niobium, tantalum, and tungsten, the glass having a content of Fe_2O_3, such content not exceeding, respectively, in the cases of the compounds named, 0.03, 0.025, 0.15, 0.35, 0.5, 0.35, 0.6, 0.7, and 0.2%.

Glass-cutting apparatus. G. L. LEE (Landon P. Smith, Inc.). U. S. 2,096,284, Oct. 19, 1937 (April 22, 1936).

Glass for discharge tube. N. V. PHILIPS' GLOEILAMPENFABRIEKEN. Fr. 809,014, Feb. 22, 1937; *Chem. Abs.*, **31**, 6841 (1937).—Glass is made resistant to the action of metal vapors by coating it with a film of alkali or alkaline-earth metal oxide or Al_2O_3. Thus the glass may be brought into contact with the vapor of the metal, the oxide of which is to be formed, and heated until it is physically attacked by the metal, after which the metal is oxidized.

Glass-drawing apparatus. E. DELACUVELLERIE. Brit. 471,027 Sept. 8, 1937 (Jan. 10, 1936).

Glass feeding apparatus. W. L. MCNAMARA (Capstan Glass Co.). Can. 368,644, Sept. 14, 1937 (Jan. 17, 1936; in U. S., Jan. 19, 1935). G.M.H.

Glass manufacture. A. F. TREMBLAY (Kent-Owens Machine Co.). U. S. 2,094,626, Oct. 5, 1937 (Dec. 30, 1935). In a glassware machine, a parison receiving unit

comprises a bottom plate and a guide, means to deposit a parison on the bottom plate, and means to position the guide adjacent to, but normally out of contact with, the parison.

Glassmelting furnace. J. A. TASSICK (Owens-Illinois Glass Co.). U. S. 2,098,440, Nov. 9, 1937 (June 26, 1933). In combination, a glassmelting furnace includes a side wall having an outlet opening through which glass is adapted to flow from the furnace, a furnace extension exterior to the wall and including a bottom wall disposed at approximately the same level as the bottom of the furnace, side walls for the extension, an upstanding wall at the outer end of the extension, a forebay having its outer margin defined by the upper part of the upstanding wall, the forebay providing an exposed gathering area of glass, a jack arch defining the inner margin of the gathering area, a conditioning chamber overlying the furnace extension between the jack arch and side wall of the furnace, means for regulably controlling the temperature in the chamber, and a vertically movable gate interposed between the side wall and the conditioning chamber for regulably controlling the highest level at which glass may enter the furnace extension.

Glass-to-metal seal. E. E. BURGER AND A. W. HULL (Canadian General Electric Co., Ltd.). Can. 365,044, March 30, 1937 (Nov. 28, 1934). An essentially strain-free seal comprises a glass in fused combination with a metal or alloy having a transformation zone below the annealing temperature of the glass and has a thermal expansion characteristic which substantially matches that of the metal or alloy at below and above the transformation zone, at least up to the softening point of the glass. G.M.H.

Glass stopper and bottle grinding machine. J. H. ROBERTS AND C. V. ACHAUER (Hazel-Atlas Glass Co.). U. S. 2,097,575, Nov. 2, 1937 (Aug. 26, 1936).

Glass tempering method. W. W. SHAVER (Corning Glass Works). Can. 368,752, Sept. 21, 1937 (July 31, 1935). G.M.H.

Glass transfer mechanism. G. R. HAUB (Hazel-Atlas Glass Co.). U. S. 2,098,624, Nov. 9, 1937 (Jan. 29, 1936).

Glassware forming machine. L. D. SOUBIER (Owens-Illinois Glass Co.). U. S. 2,098,435, Nov. 9, 1937 (Jan. 24, 1935).

Laminated glass. F. L. BISHOP (American Window Glass Co.). Can. 369,433, Oct. 26, 1937 (April 6, 1934). E. L. FIX (Pittsburgh Plate Glass Co.). Can. 369,120, Oct. 5, 1937 (July 4, 1936). See *Ceram. Abs.*, **15** [9] 275 (1936). G.M.H.

Laminated glass. J. F. WALSH (Celluloid Corp.). Can. 363,824, Feb. 2, 1937 (April 8, 1931). Comprising sheets of glass having interposed therebetween a plastic sheet containing a cellulose ester and a plasticizer therefor and having a resin or gum homogeneously incorporated therein, formed by pressing the plastic sheet between uncoated sheets of glass. G.M.H.

Laminated glass and process for preparing. WALTER BAUER AND ADOLF GERLACH (Röhm & Haas Co.). U. S. 2,095,944, Oct. 12, 1937 (Oct. 19, 1932).

Leer for annealing glassware. T. F. PEARSON. Brit. 471,567, Sept. 22, 1937 (May 25, 1936).

Leer loader. J. W. ROSS (Hazel-Atlas Glass Co.). U. S. 2,094,497, Sept. 28, 1937 (April 28, 1936).

Making hollow articles of wired glass. GLASHÜTTENWERKE PHOENIX G.M.B.H. Ger. 647,268, July 1, 1937; Cl. 32*a*. 22; *Chem. Abs.*, **31**, 6841 (1937).

Making multifocal lens. D. F. TAYLOR (Continental Optical Co., Inc.). U. S. 2,097,001, Oct. 26, 1937 (May 8, 1933).

Manufacture of glass. C. ARNOLD (Non-Metallic Minerals, Inc.). Brit. 472,027, Sept. 29, 1937 (March 1, 1937).

Manufacture of glass bottles. D. D. GORDON (Dominion Glass Co., Ltd.). Can. 364,810, March 16, 1937 (Dec. 3, 1935). A method of manufacturing a glass bottle consists in producing a hollow glass parison having an outwardly facing bottom cavity, displacing a portion of the glass into the cavity to form an inwardly facing well communicating with the hollow interior of the parison, and expanding the parison to its final shape. G.M.H.

Manufacture of lenses. J. H. MARTIN (V. H. Hancock). U. S. 2,096,751, Oct. 26, 1937 (July 8, 1933; renewed April 25, 1936).

Manufacturing multipart glass articles. W. P. ZIMMERMAN AND M. K. HOLMES (Owens-Illinois Glass Co.). U. S. 2,094,287, Sept. 28, 1937 (May 13, 1935; renewed April 27, 1937). The method of producing a hollow glass building block consists in molding hollow sections having edge portions adapted to be united, dipping the edge portions while hot into a bath of molten aluminium and retaining the edges in the bath a sufficient period of time to substantially equalize the temperatures of the edges and bath and thereby coat the edges with aluminium, and bringing the coated edge portions into contact with each other under pressure.

Marking polished glass articles. T. B. DRESCHER (Bausch & Lomb Optical Co.). U. S. 2,093,601, Sept. 21, 1937 (Nov. 22, 1934).

Means and method of controlling temperature and condition of glass in a forehearth. W. T. HONISS (Hartford-Empire Co.). U. S. 2,098,625, Nov. 9, 1937 (Jan. 5, 1934).

Means for skimming glass in forehearth of glassmelting furnace. T. F. PEARSON. Brit. 471,990 to 471,992, Sept. 29, 1937 (May 2, 1936).

Means for tempering glass. GILT EDGE SAFETY GLASS, LTD., H. PERRY, AND A. W. GROTEFELD. Brit. 473,065, Oct. 20, 1937 (March 5, 1936).

Method and apparatus for forming hollow glass articles. G. E. HOWARD (Hartford-Empire Co.). U. S. 2,098,186, Nov. 2, 1937 (Sept. 11, 1935).

Method and apparatus for producing hollow glass articles. L. D. SOUBIER (Owens-Illinois Glass Co.). U. S. 2,094,624, Oct. 5, 1937 (Feb. 9, 1934; renewed Jan. 6, 1937).

Multifocal lens. L. W. SNYDER. U. S. 2,097,260, Oct. 26, 1937 (May 7, 1935).

Optical glass. L. W. EBERLIN (Canadian Kodak Co., Ltd.). Can. 368,794, Sept. 21, 1937 (Sept. 1, 1936). G. W. MOREY (Canadian Kodak Co., Ltd.). Can. 368,-793, Sept. 21, 1937 (Aug. 28, 1936). G.M.H.

Optical lens. V. H. HANCOCK. U. S. 2,097,369, Oct. 26, 1937 (Jan. 11, 1937).

Process and apparatus for making glass cylinders or tubing. CORNING GLASS WORKS. Brit. 472,525, Oct. 6, 1937 (April 10, 1936).

Process and apparatus for tempering glass sheets. A. QUENTIN. Brit. 471,144, Sept. 8, 1937 (May 23, 1936).

Process and device for conditioning glass in manufacture of articles with a tank furnace. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Brit. 473,938, Nov. 3, 1937 (Jan. 8, 1936).

Process and means for grinding or polishing glass surfaces. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Brit. 471,163, Sept. 8, 1937 (May 4, 1935).

Producing colored and tempered glass sheets or plates. AMERICAN SECURIT CO. Brit. 473,947, Nov. 3, 1937 (Feb. 21, 1936).

Production of compound glass or other laminated products. A. KAMPFER. Brit. 472,140, Sept. 29, 1937 (Feb. 13, 1936).

Production of hollow glass units. WEBB'S CRYSTAL GLASS CO., LTD., R. W. JOHNSTON, AND J. H. NORTHWOOD. Brit. 473,735, Nov. 3, 1937 (Oct. 26, 1936).

Production of safety glass. W. KONIGSWARTER AND L. FEJES (trading as Elektroösmose (Graf Schwerin Ges.)). Brit. 470,135, Aug. 25, 1937 (July 14, 1936).

Safety glass. D. MEYER. Brit. 471,904, Sept. 29, 1937 (March 25, 1935). W. E. NOBBE (Libbey-Owens-Ford Glass Co.). U. S. 2,094,183, Sept. 28, 1937 (Dec. 5, 1933).

Safety take-out for glassware making machines. EDWARD MILLER (Lynch Corp.). U. S. 2,097,130, Oct. 26, 1937 (Oct. 9, 1933).

Sheet-glass apparatus. F. R. HOHMANN (Libbey-Owens-Ford Glass Co.). U. S. 2,094,403, Sept. 28, 1937 (Dec. 13, 1933).

Suction device for withdrawing molten glass from a tank furnace. T. F. PEARSON. Ger. 647,204, June 29, 1937; Cl. 32*a*. 6; *Chem. Abs.*, **31**, 6841 (1937). See Brit. 441,682 (*Ceram. Abs.*, **15** [5] 150 (1936)).

Tempered glass article and method of manufacture. BERNARD LONG (Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St.-Gobain, Chauny & Cirey). U. S. 2,097,073, Oct. 26, 1937 (June 29, 1935).

Tempering glass. GILT EDGE SAFETY GLASS, LTD., H. PERRY, AND A. W. GROTEFELD. Brit. 473,066, Oct. 20, 1937 (March 6, 1936). HERZOGENRATHER GLASWERKE BICHEROUX & CIE, GES. Brit. 471,813, Sept. 22, 1937 (March 13, 1935). A. QUENTIN. Brit. 472,022, Sept. 29, 1937 (Feb. 8, 1937). SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Brit. 472,908, Oct. 13, 1937 (April 6, 1935).

Tempering sheets or articles of glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Brit. 472,907, Oct. 13, 1937 (April 10, 1935).

Tumbler decorating machine. H. R. SCHUTZ (Libbey Glass Co.). U. S. 2,097,135, Oct. 26, 1937 (Feb. 4, 1935).

Treating glass. A. J. M. MILLER. Brit. 473,749, Nov. 3, 1937 (March 18, 1937).

Structural Clay Products

Invisible fissures, their formation, and means of avoiding them. F. W. HISSCHEMÖLLER. *Med. Lab. N. N. Vlamovenstaatklinker*, 1936, No. 6, pp. 183–206; abstracted in *Chimie & Industrie*, **38** [2] 301 (1937).—These cracks occur before firing of the brick and depend on the properties of the clay (shrinkage, plasticity, elasticity), humidity, direction and velocity of wind, and dimensions of the brick. They appear especially during drying when the water content of the clay reaches a critical value (5.5% for the clay examined). These fissures do not appear in frozen brick. Measures used to diminish their formation are (1) lowering of the interior tensions by slowing down the rate of drying, (2) preventing the reabsorption of atmospheric humidity by the dried brick, and (3) regulating drying in air and in the furnace. M.V.C.

Kinetics of the carbonation processes of lime-sand autoclaved materials. E. S. ORDYNSKAYA, N. N. PETIN, AND M. I. KHIGEROVICH. *Zhur. Priklad. Khim.*, **10** [2] 290–99 (1937).—The carbonation usually begins chiefly on the surface of lime-sand brick; it progresses more energetically in the case of moist carbon dioxide. The diffusion of CO_2 into the interior of the brick is extremely slow on account of the high moisture content of the brick. A considerable carbonation takes place during the preparation of the samples and their storage. Moist carbon dioxide is absorbed in a considerably greater amount than dry CO_2. With carbonation by CO_2 in the gas phase, the mechanical strength of artificial lime-sand brick grows slightly and in any case does not decrease. A relatively large increase of strength takes place under the influence of moist carbon dioxide. The above observations confirm the practical observations on the stability of artificial lime-sand brick to the influence of atmospheric conditions. P.B. & E.S.

Manufacture of salt-glazed stoneware pipes and fittings. A. COULHON. Translated in *Brit. Clayworker*, **46** [545] 180–83 (1937).—C. discusses the atmosphere in kilns and points out that a neutral atmosphere is the most desirable. The scientific control of the firing of pipe kilns is little understood; it is very rare to find works even using pyrometers. The salting operation is described. See *Ceram. Abs.*, **16** [11] 342 (1937); also this issue, p. 25. R.A.H.

Origin of weathering surfaces on building stones. ANNEMARIE SCHMÖLZER. *Chem. Erde*, **10** [4] 478–517 (1936).—From observation and analysis of weathered portions of stone buildings, S. concludes that destruction of the surfaces exposed is largely the result of deposition and hydration of water-soluble salts aided by volume changes because of frost and dampness. The action of algae and lichens are sometimes of importance. Wind erosion is of little effect in European climates. The effect of bacteria is little known. See "Testing—," *Ceram. Abs.*, **16** [9] 283 (1937). H.I.

Properties of mortar for use in unit masonry construction. LEE S. TRAINOR. *Bull. Amer. Ceram. Soc.*, **16** [11] 430–34 (1937).

Results from use of plasticized sulfur as a jointing material for clay products. W. W. DUECKER AND H. Z. SCHOFIELD. *Bull. Amer. Ceram. Soc.*, **16** [11] 435–38 (1937); see *ibid.*, **14** [10] 329 (1935).

BULLETINS

Damp-proof courses for brickwork structures. L. W. BURRIDGE. *Clay Prod. Tech. Bur. Gt. Brit., Tech. Bull.*, No. 4, 4 pp. (1937).—Damp-proof courses for stopping the passage of ground moisture into masonry walls are of two types, flexible and rigid. The flexible types are bitumen or sheet lead and iron or copper. The rigid type is built up as part of the masonry, consisting of two or three courses of vitrified brick, slate, or granite, laid up in impervious mortar. The danger of weak bond with the flexible type prompts a detailed description of the rigid type. F.T.HEATH, JR.

Efflorescence and staining on brickwork. L. W. BURRIDGE. *Clay Prod. Tech. Bur. Gt. Brit., Tech. Bull.*, No. 3, 4 pp. (1937).—The causes of efflorescence and staining on brickwork and the wick test for efflorescence on brick are described. Methods of avoiding efflorescence in new construction and of treating it in existing structures are discussed, specifications of suitable mortars being given. B. deals with staining due to metallic corrosion, mold growths, and lime leached from associated concrete lintels and other cement products. Many conclusions accepted by U. S. authorities are confirmed, and phases of this problem not heretofore covered are developed. F.T.HEATH, JR.

PATENTS

Brick-roughening machine. D. WHITEHOUSE AND MARSTON VALLEY BRICK CO., LTD. Brit. 473,394, Oct. 27, 1937 (Jan. 7, 1937).

Heat-insulating wall. F. C. REINKE (Air-O-Cel Industries, Inc.). U. S. 2,098,554, Nov. 9, 1937 (July 14, 1936).

Machinery for making rustic brick. H. S. HASLER. Brit. 473,731, Nov. 3, 1937 (Oct. 10, 1936).

Paving brick. O. W. RENKERT (Metropolitan Paving Brick Co.). U. S. 2,095,012, Oct. 5, 1937 (Sept. 8, 1936). In a brick pavement, a plurality of brick laid end to end, each brick having spacing lugs on one side and two diagonally spaced lugs on each end located in laterally opposite portions thereof, all of the brick having their side spacing lugs facing in the same direction, and the lugs of each end abutting the end face of an adjoining brick regardless of whether the top or bottom faces of either of two adjoining brick are placed uppermost.

Skip for handling brick stacks. D. J. STRICKLAND. U. S. 2,094,762, Oct. 5, 1937 (Nov. 9, 1936).

Refractories

Accelerated firing of silica brick from crystalline Ural quartzites in periodic furnaces. V. D. TSIGLER. *Ogneupory*, **5** [1] 7–13 (1937).—The quality of silica brick for crowns of Siemens-Martin and electric furnaces was improved by accelerating the rate of firing and cooling of the brick. M.V.C.

Artificial clay-like state of super refractory materials. B. YA. PINES AND E. I. TER-MIKAELYANTS. *Ogneupory*, **4** [3] 74–84 (1936).—Wet crushing of refractory minerals, such as dead-burned chromite or magnesite, produces plastic mixtures which yield refractories with better properties than those manufactured by ordinary methods. The addition of wet-ground mixes as bond also yields good results. M.V.C.

Attempts to manufacture refractory materials, according to the semidry method, from grog fired at low temperature. I. I. KUZMENKO. *Ogneupory*, **5** [2] 85–93 (1937).—Laboratory experiments showed that the brick obtained were of high quality. They have a high mechanical and thermal strength and are resistant to the attack of slag. Directions for manufacturing such brick are given. M.V.C.

Calculating the firing of dolomite in shaft furnaces. L. P. VLADIMIROV. *Metallurg*, **10** [9] 50–71 (1935); abstracted in *Chem. Zentr.*, **1936**, ii, 529. M.V.C.

Chrome and refractory materials. C. MORE. *Argile*, No. 171, pp. 17–23 (1937).—The largest chromite deposits are found in Rhodesia, New Caledonia, Turkey, and the U.S.S.R. The French chromite with 55 to 58% of Cr_2O_3 is of excellent quality. It is chiefly used for neutral bottoms of open-hearth furnaces in which blocks of raw chromite are used. These blocks should not contain less than 40% Cr_2O_3. The analysis of various chromites is given. Chromite refractories (1) are practically unattackable by basic flux materials and are decomposed by bisulfates of Na, OH, and CaO; (2) are little affected by acid fluxes; (3) are not oxidized by air; (4) are reduced to ferrochrome at high temperatures by C and reducing gases; (5) are unaffected by fused metals without oxides; (6) have melting points from 1900° to 2000°C; and (7) are resistant to pressure under load up to 1400° and 1500°. Data on chromite refractories manufactured by two German companies and a table with comparative properties of chromite, silica, and magnesite refractories are given. M.V.C.

Colored spots in silica brick. V. N. SHVETSOV. *Ogneupory*, **4** [9] 560–63 (1936); abstracted in *Chimie & Industrie*, **38** [2] 303 (1937).—Colored spots are often observed on the surface of silica brick; they are due to a high alumina or iron oxide content. An insufficiently high temperature of firing (below 1350°) promotes their appearance. M.V.C.

Comparison of methods for evaluating the quality of silica brick. A. M. TRAKHTENBERG. *Ogneupory*, **5** [1] 33–46 (1937).—Methods used for evaluating silica brick consist in determining density, microstructure, and thermal coefficient of expansion. The latter method is the most suitable as it yields the best information on the behavior of brick under conditions which prevail in technical operation. M.V.C.

Compound refractories with high grog content. G. O. GROSS. *Ogneupory*, **5** [2] 98–100 (1937).—G. discusses

mechanics of the phenomena occurring during the action of molten materials on refractories manufactured by the slip method. The addition of ground special refractory materials, such as zircon, chromite, magnesium silicates, and aluminosilicates, is analyzed. M.V.C.

Deformation and Young's modulus of fireclay brick in flexure at 1220°C. RAYMOND A. HEINDL AND WILLIAM L. PENDERGAST. *Jour. Research Nat. Bur. Standards*, 19 [3] 353–66 (1937); R.P.1030. Price 10¢.—The total deformations (plastic and elastic) of 17 brands of fireclay brick in flexure at 1220°C were determined after reheating at 1400 and 1500°C. Similar information was obtained on 8 of the 17 brands as received from the manufacturer, the remaining 9 having failed before deformation data could be obtained. Young's modulus of elasticity in flexure and the modulus of rupture were determined at approximately 6 lb./in.² applied midspan to a 1 x 1 x 9-in. specimen on an 8-in. span. The modulus of elasticity and strength were determined on the same type of specimen and span; the load increments were varied according to the strength of the specimen. The following results were obtained: (1) Total deformation of specimens heated at 1400°C increased, in general, with increase in quantity of particles in the raw brick batches retained on a U. S. Standard sieve No. 40. (2) Data indicate that brick of the dry-press type have uniformly high deformations, the stiff-mud type, with one exception, have low deformations, and the handmade type have deformations intermediate of the range of the two other types. (3) Brick of the lowest ratio of total flux to total silica have much less deformation than those having the highest ratio. (4) Deformation decreased greatly in most cases when specimens were given preliminary reheat treatments at 1400 and 1500°C. With one exception, the brick high in silica showed the least change in deformation after the reheat treatments. The petrographic examination showed successive decreases in glass content and increases in the crystallization of mullite with reheating. Specimens showing low deformation when tested as received either were of the siliceous type or contained considerable quantities of mullite crystals. Much glass was present in those showing high deformations. (5) Although there are exceptions, the total deformations of the limited number of materials tested do indicate a trend, *i.e.*, deformations increase as the quantity of coarse aggregate and ratio of flux to silica increases. After reheating at 1500°C, particle size is apparently no longer an important factor. (6) Young's modulus of elasticity of specimens in flexure as received from the manufacturer was less than 200,000 lb./in.² for 11 of the 17 specimens; it was about twice as great after reheating at 1400°C. The strength of the reheated specimens also increased greatly in most cases. R.A.H.

Determining refractoriness of carbon-containing refractory materials. D. A. NIRENSHTEIN. *Zavodskaya Lab.*, 6 [3] 357–58 (1937).—The cone under test is installed on a support inside a hollow cylinder, and a small layer of cryptol is strewn on the support. The temperature is measured from above with the aid of an optical pyrometer. In this way the carbon does not burn out, and the determination is correct. P.B. & E.S.

Development of laboratory tests for high temperature cements. J. F. MCMAHON. *Jour. Can. Ceram. Soc.*, 6, 55–65 (1937).—McM. discusses research carried out to evolve a method of test applicable to high-temperature cements marketed for use in laying up fireclay brick in the fire walls of stationary boilers. J.G.P.

Hearth refractories for steel making. W. J. MCCAUGHEY AND H. C. LEE. *Metals & Alloys*, 8 [6] 153–57 (1937).—Acid open-hearth and Bessemer processes of steel making, as practiced in America, employ hearth refractories high in silica. Successful application of basic open-hearth process, now of greatest importance, requires a hearth refractory resistant to the corrosive effect of iron oxide dissolved in the basic slag, and calcined dolomite and magnesite are separately used. Clinkered dolomite possesses quick coalescing properties but its high lime content shortens its life; magnesite, on the other hand, is slow setting, although long-lived. To meet the need for a magnesite refractory with high magnesia content and the quick coalescing properties of clinkered dolomite, Thomasite was developed. This contains 2.5 SiO_2, 7.0 Fe_2O_3, 1.0 Al_2O_3, 10 CaO, and 79.5% MgO; the final hearth refractory is essentially 79% periclase bonded with calcium ferrite. Sufficient calcium ferrite (16%) is formed at furnace temperatures to set the refractory rapidly; at the same time, the MgO content is high enough to provide long life. F.P.P.

High alumina bodies: VI, Coarse-grained andalusite bodies. YA. V. KLYUCHAREV AND I. I. VORONIN. *Ogneupory*, 4 [7] 483–93 (1936).—Studies of Russian andalusites showed that the manufacture of refractory andalusite products with small amounts of bonding clay is possible only with pure andalusites containing 1% alkalis at the most and at least 58% Al_2O_3. The firing temperature should not be lower than 1550°. **VII, Technical properties of bodies with high alumina content.** YA. V. KLYUCHAREV. *Ibid.*, [12] 783–91; abstracted in *Chem. Zentr.*, 1937, ii, 1064.—K. deals with properties of raw materials, manufacturing methods, properties of finished products, and application in industries. M.V.C.

Hot-face insulation. H. V. ALLEN. *Trans. Ceram. Soc.*, 35 [10] 437–68 (1936).—The important physical and chemical properties of an insulating refractory brick are enumerated and discussed with respect to its utilization as hot-face insulation in furnace and kiln construction. The histories of a number of installations of hot-face insulation in the heavy clay and pottery industries effecting marked economies in operation are given. R.H.H.P., JR.

Improving quality of spouts and plugs. A. I. SIDORENKO. *Ogenupory*, 5 [3] 211–14 (1937).—To improve the density and therefore the resistance of spouts and plugs used in steel casting, 5 to 8% feldspar (used as flux) was added to the raw grog materials rich in alumina. M.V.C.

Insulating refractory brick—their properties and application. A. V. LEUN. *Trans. Amer. Foundrymen's Assn.*, Preprint 37-23, 13 pp. (1937); *Metals & Alloys*, 8 [9] MA549 (1937); see *Ceram. Abs.*, 16 [9] 276 (1937).

Insulation of soaking pits improves operation. S. M. JENKINS. *Steel*, 98, 64–68 (March 9, 1936).—The important part that insulation plays in the advancement of soaking-pit equipment is pointed out. The latest soaking pits are brick insulated with a sheet steel outer casing or

incased with a concrete outer wall. When soaking-pit regenerators are encased with steel shell or concrete the infiltration of air is prevented. This air infiltration, if through the pit, cools the ingots and gives them uneven temperatures and, if through the regenerator walls, lowers the temperature of the preheated air. Insulation also protects the steel casing or concrete outer wall and makes it practical and possible. Insulating brick wall construction gives a much more uniform temperature in the regenerator. Increase in heat storage in firebrick walls gives uniform expansion to the fire brick and eliminates spalling. The uniform temperature eliminates most of the rolling difficulties through the uniform heating of the ingots. J. presents data to prove the claims for insulation of soaking pits and gives a table showing a recommended insulation for an ideal soaking pit. H.E.S.

Interreaction between lime and quartzite powder during silica brick manufacture. S. L. GERMAN. *Ogneupory*, 5 [4–5] 300–304 (1937).—Tiny calcium silicate granules are formed on quartzite grains during firing. The presence of calcium silicate improves the strength of brick. M.V.C.

Lightweight refractory materials in industrial furnaces. B. N. YELTYSCHEV. *Vestnik Metalloprom.*, 16 [16] 44–57 (1936); abstracted in *Chem. Zentr.*, 1937, ii, 837.—Y. gives data on the use of lightweight refractories as furnace linings in furnaces operating periodically and those operating at high temperatures. M.V.C.

Manufacture of refractory articles from pure oxides of high melting point. J. H. PARTRIDGE AND J. R. LAIT. *Jour. Soc. Glass Tech.*, 20 [80] 200–17 (1936).—The manufacture of crucibles, rods, and tubing from Al_2O_3, MgO, BeO, ThO_2, and ZrO_2 is discussed. Extrusion, slip casting, and temporary bonding agents are used. Firing shrinkage is controlled by particle-size grading, variation of amount of plasticizer, and use of precalcined material. The chemical, thermal, and electrical properties are briefly discussed. The porosity and mechanical strength are often modified considerably by the addition of relatively small amounts of other substances. C.J.P.

Manufacture of silicon carbide heaters. N. N. NOVIKOV. *Ogneupory*, 4 [3] 98–102 (1936).—It was found that heating elements of the Silit and Globar types represent silicon carbide cemented by secondary silicon carbide formed under the effect of silica vapors on the carbon bond (tar, molasses, flour). M.V.C.

Manufacturing grog products with constant gas permeability. R. T. MAKHL. *Ogneupory*, 5 [4–5] 280–84 (1937).—Experiments showed that products with a constant gas permeability may be obtained when using a predetermined modulus of granulation as a characteristic of the granulometric composition of grog. M.V.C.

Manufacturing lightweight refractories. V. M. STRELETS. *Ogneupory*, 4 [10] 627–31 (1936); abstracted in *Chimie & Industrie*, 38 [2] 303 (1937).—The composition is 33 clay, 20 grog, 37 charcoal, and 10% sawdust. The properties are as follows: 38% moisture content of the mix, 4% shrinkage in air, 10% shrinkage after firing at 1300°, and 0.5% density after firing. M.V.C.

New type of thermal shock. A. C. ELLIOTT AND R. J. MONTGOMERY. *Jour. Can. Ceram. Soc.*, 6, 44–48 (1937).—While testing northern Ontario fire clay, the authors developed a new type of spalling test. Two furnaces were used. Furnace No. 1 was held constant at a selected temperature which varied from 900° to 1100°C, depending upon the refractoriness of the clay being tested. Furnace No. 2 was held at a lower temperature. For the first run of the test, furnace No. 2 was held at 100°C below that of furnace No. 1. Three test bars $^3/_4$ x $1^1/_2$ x 4 in. in size, which had previously been well fired and slowly cooled, were slowly heated in furnace No. 1 as it was brought up to the selected constant temperature; 3 hr. were required. The test bars were then transferred to furnace No. 2, giving a thermal shock of 100°C sudden temperature change. After 15 min. to equalize the temperature, the bars were transferred back to furnace No. 1, giving a further thermal shock of 100°C temperature increase. The above procedure was repeated until three cycles were completed and the test pieces were again in furnace No. 1. After slow cooling, the transverse strength of the test bars was determined in the usual way, and this strength was compared with the strength of pieces not exposed to the thermal shock. The per cent loss in strength was also recorded. Furnace No. 2 was then held at 200°C below the temperature of furnace No. 1, and the three-cycle test was repeated on fresh samples. After each run, the temperature of furnace No. 2 was lowered another 100°C, and the temperatures at which partial and total loss of strength occurred were determined. In some cases, 50°C intervals were used to give more detailed data. An average value for three test bars was sufficient to obtain consistent results, and the agreement from bar to bar was very good, indicating the results to be a fair index as to the condition of the pieces. The three clays tested were (*a*) Lorraine shale, Toronto district, P.C.E. 3, (*b*) fire clay (No. 169) from the Onakawana River deposit in northern Ontario, P.C.E. 26, and (*c*) English china clay, a commercial sample of medium plasticity. The test as outlined is severe enough to bring out the critical spalling temperature. The slope of the "loss of strength" curve seems to be directly related to the "temperature of plastic flow" curve. Curves suggest an explanation of why Lorraine shale does not resist spalling to any degree; why fire clay No. 169 could not be used by itself for assay crucibles; and why thermal shock does not usually result in total loss of strength of English china clay. More work will have to be done to establish such points as (*a*) proper firing temperature for samples before testing, (*b*) proper temperature for furnace No. 1 during test, (*c*) effect of repeated heatings upon the properties involved, and (*d*) effect of adding grog. J.G.P.

Open-hearth insulation advances. ANON. *Steel*, 98 [1] 240, 336, 337 (1936).—Many new devices have been placed in operation in the open-hearth within the past year. Furnace insulation and design have shown material progress and some saving in fuel costs. Newer and higher melting-point refractories have been developed by the use of insulation. The effect of automatic draft control on refractories has been to increase the life of the backwalls and endwall bulkheads. One 120-ton furnace has just completed a record campaign of over 500 heats without a patch on the insulated roof and with the roof in such good condition that it is being left intact for another campaign. H.E.S.

Physical properties of magnetite and its possible use as an industrial mineral. R. S. Dean and C. W. Davis. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 795, 11 pp. (1937); *Mining Tech.*, 1, No. 2 (1937).—Among other uses, magnetite is added to dead-burned magnesia partly as a bond and partly because it helps in the conversion of amorphous magnesia to crystalline periclase. W.D.F.

Physical properties of silicon carbide refractories. H. N. Baumann, Jr., and J. P. Swentzel. *Bull. Amer. Ceram. Soc.*, 16 [11] 419–30 (1937).

Practical tests on refractory mixes. W. E. Patterson. *Jour. Can. Ceram. Soc.*, 6, 38–44 (1937).—The fusion point of coal ash may vary over wide limits, ranging from around 2100° to 2900°F, depending on the composition of the ash. The effect of ash fusion point on refractory furnace linings constitutes a problem which is further complicated by the difficulty of testing refractory mixes under conditions comparable to those encountered in service. A furnace was designed to simulate service conditions, the refractory test pieces being 11 x 13 x 8 in. Oil firing was used, and the hot part of the flame was made to impinge on the refractory test block. Two test pieces were placed as an integral part of the back wall of the furnace about 2 ft. apart, while the furnace itself is a simple rectangular type, 6 ft. long, 1½ ft. wide, and 5½ ft. high inside with two 6-in. burner ports in one side and three hot vents in the roof. The effect of slag impingement was secured by grinding low fusion ash coal with fuel oil and burning this mix in the one burner, having its flame impinge on the one test block, while the same oil without coal was used as fuel on the other. The oil-coal mixture was charged into an ordinary spray-painting reservoir fitted with a hand agitator to prevent settling of the coarser coal particles. Temperatures on the hot face of the test blocks varied from 2700° to 2900°F maximum, depending on the furnace operation. Temperatures were taken with an optical pyrometer every hour during the test, and the temperatures of the two test blocks were maintained as nearly the same as possible. The first test blocks used consisted of first-grade fire brick set with fireclay mortar. The failure of these blocks was much faster with the coal-oil fuel than with the straight oil fuel, indicating that this method of test produced results comparable with practice. The results of the test on firebrick blocks are discussed. A recognized brand of plastic fire brick was next tried, and the effect was studied. In this case also, failure was similar to that obtained in service with low fusion ash coals. With chrome blocks, the typical spalling found in service resulted from the attack of the oil-coal flame. By altering the proportion of grain sizes in the preparation of the chrome blocks a more dense refractory was obtained. This block was subjected to the test and a substantial improvement noted. J.G.P.

Preparation of alumina and sulfur dioxide from bauxite-gypsum mixtures. V. S. Dube, M. B. Rane, and M. Kanakaratnam. *Bull. Ind. Research Bur., Govt. of India*, No. 6 (1937).—The authors describe results of experiments in which mixtures of bauxite and gypsum in different proportions were heated to temperatures ranging from 1000° to 1280°C for a period varying from 2 to 8⅓ hr. Bauxite in amount of 2 g. was used in each experiment, and the proportion of bauxite to gypsum in the mixtures ranged from 3:1 to 1:3. A coal-fired muffle furnace was employed. The reaction between bauxite and gypsum was appreciable at 1000°C and complete at 1250°C. By mixing bauxite and gypsum in the ratio of 2:5 and heating the mixture to 1200° to 1250°C for a period of 6 to 7 hr., SO_3 was completely expelled from the gypsum, and the resulting calcium aluminate ($2CaO \cdot Al_2O_3$, $3CaO \cdot Al_2O_3$, or a mixture of both) on hydrolysis would furnish pure alumina. A.P.S.

Properties of open-hearth furnace checker brick. T. Swinden and J. H. Chesters. *Trans. Ceram. Soc.*, 35 [10] 469–85 (1936).—The physical properties of fireclay and semisilica brick which affect their use in open-hearth furnace checkers are shown to be very similar. Used checker brick, provided they are unglazed and can readily be freed from dust, can be re-used without loss in operating efficiency. Analyses of steel furnace checker dusts and of samples of slagged brick indicate that iron oxide (45%) and lime (10%) are the principal materials responsible for the corrosion of checker brick, although other oxides such as those of zinc and the alkalis may be present in considerable amounts. There appears to be no simple method of comparing the thermal efficiencies of special settings with the efficiency of those made from standard squares. R.H.H.P., Jr.

Quartzites from the Ovruch deposits. G. Taubin and B. Pindrik. *Ogneupory*, 4 [8] 505–14 (1936); abstracted in *Chimie & Industrie*, 38 [2] 301 (1937).—Crystalline quartzites of Ovruch are excellent raw materials for the manufacture of silica brick. The composition and physicochemical properties of these quartzites, however, are rather variable. The chief impurities are pegmatite, talc, rutile, and zircon. See "Silica—," *Ceram. Abs.*, 16 [9] 278 (1937). M.V.C.

Refractories with a chromite base and with increased resistance to deformation under load at high temperature. A. G. Marants. *Ogneupory*, 4 [9] 547–52 (1936); abstracted in *Chimie & Industrie*, 38 [2] 303 (1937).—When adding a mixture, $2Al_2O_3 + MgO$, to chromite, increased resistance to deformation under load is obtained; 20% is the maximum addition. The firing temperature is 1650°C. Magnesite alone can also be used with a firing temperature of 1400° to 1500°C. M.V.C.

Refractories for glassmelting with a high grog content from Druzhkovskii clays. V. A. Rybnikov, P. P. Alimova, and P. I. Katyshev. *Keram. & Steklo*, 13 [8] 16–24 (1937); *Ogneupory*, 5 [4–5] 285–89 (1937).—Chemical and ceramic tests showed that Druzhkovskii clays have a low iron oxide content (1.02%), high alumina content (40.5%), and low alkali content (0.8%). The clay is highly plastic, sinters at a low temperature (900°), and is very refractory (1730°). Grog obtained from these clays was used in the manufacture of refractories for glassmelting furnaces. Details of experiments and directions for manufacturing these refractories are given. M.V.C.

Refractories insulation. W. Trinks. *Ind. Heating*, 4 [10] 911–14 (1937). M.H.

Refractories for iron-blast furnaces. R. A. Lindgren. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 752, 16 pp. (1936); *Mining Tech.*, 1, No. 1 (1937).—The shaft and hearth of a blast furnace require different kinds of fire brick.

A good brick has been developed for the hearth but not for the shaft. An ideal brick should be exact in size and homogeneous in structure. Better methods of firing should give more accurate sizes. De-aired clay bo[illegible]s make the most homogeneous brick. Tests were made o. the disintegration of brick by carbon deposition. Carbon monoxide diffuses into the brick and is catalytically changed to carbon and carbon dioxide between 788 and 878°F. Blast-furnace gases enriched with carbon monoxide were passed over the brick at a temperature varying from 800° to 900°F and down again in about 1 hr. Brick shattered in from 2 to 7 days. Those not shattered at 7 days did not shatter later. The quantity of iron in the brick does not indicate a tendency to disintegrate. The Fe_2O_3 may cause it. This disintegration does not necessarily mean lining failure as the disintegrated brick are highly vitrified in the furnace, producing a smooth, monolithic lining. W.D.F.

Refractories meeting new demands. ANON. *Steel*, **98** [1] 237, 335–36 (1936).—With iron and steel production steadily forging upward, new demands are being imposed on refractories. Lightweight refractories and insulation have been increasing steadily. There is also an increase in the use of improved Metalkase brick as well as unfired chrome brick. The forsterite or olivine refractory has extended its applications in such equipment as open-hearth bulkheads and copper furnaces. Chrome brick made under the Ritex process continue to displace silica brick above the slag line in basic open hearths. The introduction of a new type of melting furnace into the malleable and gray iron casting industry points to the entrance of silica brick into a field long dominated by refractories of the fireclay type. Super fireclay brick has met with increasing use in malleable furnace bottoms. New methods of manufacturing insulating brick in which gels are used as setting-up agents are being tried. One of the fundamental effects of complete furnace insulation which leads to longer furnace life is the reduction of the temperature gradient through the refractory cross-section, and this principle, as it affects important crystalline changes in the structure of the refractory, is being applied to advantage in numerous furnaces. In general, users of refractories are becoming more conscious of the quality of refractories as determined by the chemical and physical properties. H.E.S.

Refractories—recent types, uses, and unit costs. O. L. DAY. *Metal Progress*, **30** [4] 59–63, 72, 82 (1936).—Refractories are classified as (1) fireclay brick and ground fire clay, (2) high alumina clay brick, (3) silica brick, (4) basic brick and loose refractories, and (5) high-temperature cements. The method of manufacture, typical applications, and cost of each type are given. Fire clay is the most widely used, particularly in the steel industry. Alumina refractories may economically replace fire clay for use at temperatures slightly below the incipient fusion point of the latter. The cement industry is the largest user of alumina brick. Present research on alumina brick is directed to (1) eliminate the high porosity of the fired material, (2) induce the growth of mullite in the 70% Al_2O_3 class or stable corundum in the 80% Al_2O_3 class, and (3) ultilize bauxite to produce refractories comparable with those made from the diaspore clays. Silica brick has higher physical strength but greater sensitivity to thermal shock and higher thermal conductivity than clay brick. The use of the basic refractories (magnesite, chrome, and dolomite) and the development of high-temperature cements are also discussed. F.P.P.

Relation between the calcining temperature of dolomite and the quantity of heat evolved by interaction of the calcined product with water. P. P. BUDNIKOV AND L. G. GULINOVA. *Zhur. Priklad. Khim.*, **10** [5] 797–806 (1937). P.B. & E.S.

Resistance to compression of refractory brick. F. CASAR. *Ber. Deut. Keram. Ges.*, **17** [7] 370–72 (1936).—Studies made on the effect of manufacturing methods on the resistance of refractory brick to compression are reported. C. points out that chemical analysis, porosity, softening behavior, and resistance to temperature changes and slag attack are more important properties of refractories than is the resistance to compression. E.J.V.

Semiacid grogless refractory for casting pipes. V. N. SHVETZOV. *Ogneupory*, **5** [3] 224–26 (1937).—Steel casting pipes manufactured from several types of Ural clays, in which the usual addition of grog was replaced by quartz sand, have a high melting temperature of 1670 and 1690°C. M.V.C.

Silica brick containing chromite. L. KUPRIYANOVA. *Ogneupory*, **4** [9] 554–59 (1936); abstracted in *Chimie & Industrie*, **38** [2] 303 (1937).—The introduction of chromite into silica brick lowers the mechanical resistance of the brick because of the difference in the coefficients of expansion of chromite and of quartzite, producing cracks. The transformation of quartzites into tridymite diminishes the formation of cracks; this transformation is promoted by adding mineralizers and by increasing the duration of firing. Chromite is a mineralizer liberating iron oxide on decomposition. The addition of chromite (up to 25%) to silica brick does not increase the refractoriness of the brick; its only advantage is that it increases the resistance of the brick to the attack of slag. M.V.C.

Silica firestone refractories. E. A. BURR. *Ind. Heating*, **4** [7] 581–83; [8] 642–46; [9] 755–60 (1937).—Silica firestone refractories are natural products hewn from quarries and have the composition SiO_2 93.13, Al_2O_3 3.86, Fe_2O_3 0.11, FeO 0.54, MgO 0.25, and CaO 0.10%; loss on ignition 1.43%. The properties are as follows: fusion point about 3000°F, crushing strength 8000 to 10,000 lb./in.^{2}, transverse strength 1200 to 1300 lb./in.^{2}, pore space 18%, specific gravity 2.31, thermal expansion up to 2200°F 0.00000999 on first heating, and average weight of 1 cu. ft. 144 lb. B. describes methods and shape of stones to be used in lining soaking pits, furnace ladles, mixers, converters, and in foundry use and gives suggestions for handling and preparing the stones. M.H.

Specialized electric-furnace refractories. J. A. KING. *Metal Progress*, **28** [4] 27–31 (1935).—Refractories produced in the electric furnace are discussed with respect to their manufacture, properties, and applications. Electric-furnace refractories are of the silicon carbide, aluminum oxide, and fused aluminum silicate types. Their properties are tabulated and compared with those of fire clay, bauxite, silica, chrome, magnesia, and insulating brick, and the suitability of individual materials for specific high-temperature applications is indicated. F.P.P.

Taps slag from six boiler furnaces every 24 hours. J.

H. STRASSBURGER. *Steel*, **98**, 57–58 (Jan. 27, 1936).—Ash is being tapped from six pulverized coal-fired boilers thus avoiding the shutdowns occurring every 30 to 40 days when the ash was removed periodically. Slag is tapped from each boiler once every 24 hr., and the slag level is lowered from 18 to 6 in. at these periods. The furnace bottom is sloped toward the tapping hole which is one course of brick 4½ in. wide and six courses 15 in. high. When tapping slag, the top brick are removed first, and, as the slag level lowers, additional brick are taken out. Fly ash is used to keep the slag from sticking to the walls of the tapping hole, and it aids materially in keeping a steady flow of slag. Fire clay is used to seal the tapping hole on the outside. Illustrated. H.E.S.

Testing certain magnesium silicates as refractories. A. BAZILEVICH. *Mineral. Syr'e*, **10** [2] 27–30 (1935); abstracted in *Sprechsaal*, **70** [4] 47 (1937).—Talc, waste from asbestos, and talc rock were studied. The first two materials have a relatively low refractoriness but a very high resistance to alkalis, especially asbestos. Talc rock has an average refractoriness over 1800°, and the temperature of incipient deformation lies near 1526°. The talc rock contains about 50% talc, 40% $MgCO_3$, and 8 to 10% serpentine, chlorite, and magnesite. Refractoriness can be increased by concentrating with magnesite. The product obtained consists chiefly of forsterite and periclase and does not undergo the characteristic transformation of talc rock at about 1540°. This product can also be obtained from talc and waste asbestos and an addition of 50 or 30% magnesite (talc rock requires a 20% addition). M.V.C.

Tests with thermally stable brick of the Magnesite plant in crowns of Siemens-Martin furnaces. G. TASITDINOV AND A. SCHAVOROSTOV. *Ogneupory*, **4** [12] 807–10 (1936); abstracted in *Chem. Zentr.*, **1937**, **ii**, 1065.—The brick containing 50% magnesite and 50% chromite is valuable as lining for Siemens-Martin furnaces. After 181 melts of special steel, the main crown showed no marked changes; in the inclined parts of the crown, the wear out of the brick amounted to 16% after 360 melts. M.V.C.

Tests with unfired brick M-50 of the Magnesite plant in Siemens-Martin furnaces. E. KORT AND A. DRASHNIKOVA. *Ogneupory*, **4** [12] 797–806 (1936); abstracted in *Chem. Zentr.*, **1937**, **ii**, 1064–65.—The magnesite-chromite brick tested consisted of 5.0 SiO_2, 12.6 Fe_2O_3, 7.8 Al_2O_3, 3.18 CaO, 50.75 MgO, 18.57 Cr_2O_3, and 0.56% MnO; loss on ignition, 1.8%. The brick possesses a sufficient temperature stability and a low thermal conductivity; its volume stability and resistance to deformation under load at high temperature and to the attack of fused silica are satisfactory. After the first 10 or 20 melts, a gradual vitrification of the surface occurs which transforms the wall into a dense monolith. M.V.C.

Thermal insulating material from vermiculite. N. SUBAROV. *Novosti Tekhniki*, **1937**, No. 14, pp. 39–40; abstracted in *Referat. Silikatliteratur*, **4** [8] 4327 (1937).—Mineralogically, vermiculite belongs to secondary materials formed from biotite and other iron-magnesia-mica materials by hydration and reciprocal effect. Its chief property is to expand more than 20 times its original volume on heating because of the evaporation of its water content. Rich deposits of vermiculite are found in the U.S.S.R. in the Ural region. Experiments showed that the best bonding agents for the manufacture of vermiculite brick are the so-called casein glue for temperatures up to 130° and soda water-glass for temperatures up to 1000°C. A vermiculite product has a mechanical strength lower than that of cork products but it is more hygroscopic; its heat conductivity (0.060) is somewhat higher than that of cork (0.045). M.V.C.

Thermally stable magnesite refractory. V. I. KOZLOV. *Ogneupory*, **4** [3] 112 (1936).—Fired magnesite is mixed with alumina and quartzites; after firing, spinel and forsterite are obtained. The spinel products have a mechanical resistance of 750 kg./sq. cm., refractoriness is over 1920°C, and temperature of deformation is 1680° (products fired to 1720°) and 1530°C (products fired to 1600°). Forsterite products have a mechanical resistance of over 500 kg./sq. cm., and deformation under load is about 1665° (products fired at 1610°) and 1530°C (products fired at 1530°). M.V.C.

Unfired grogless refractory from Dsekh rock-like deposits. P. A. ANTIPOV. *Ogneupory*, **5** [4–5] 296–99 (1937).—Earths from Dsekh deposits were pressed into brick. A sulfite cellulose solution with a density of 20° Bé was used as bond. These brick after 12 to 14 hr. drying at 80° to 100°C showed all the properties of fired refractories with the exception of water stability. M.V.C.

Unfired refractory quartz grog brick. D. N. POLUBOYARINOV AND A. K. KARKLIT. *Zitein-Tech.-SO*, Series 27, No. 3280, 7 pp.; abstracted in *Referat. Silikatliteratur*, **4** [7] 4253 (1937).—The use of unfired grog brick is possible only when the shrinkage due to firing is compensated by admixtures which expand. The brick contain 30% bonding clay, 50% grog, and 20% quartz sand. Their low strength is a disadvantage. Molasses, pectin glue, or sulfite waste liquor improve their strength; the best results were obtained with the latter. The usual methods are employed in the manufacture of these brick. Data as to their chief properties are tabulated. M.V.C.

Using siallite-alites in refractory industry. G. PIRUMOV. *Ogneupory*, **5** [4–5] 333–42 (1937).—Bauxite deposits of the Tikhvin region contain raw materials (siallites and alites) with a high silica content which can be successfully used in the refractory industry. The refractoriness of siallites amounts to 1760° while that of alites amounts to 1770°C. The former contain not more than 3.21% Fe_2O_3 + CaO, while the latter contain not more than 5.2% Fe_2O_3 + CaO. M.V.C.

Warming up open-hearth furnaces. A. E. DODD. *Iron & Steel Ind.*, **10** [9] 372–74 (1937).—Initial heating of an open-hearth furnace requires extreme care to prevent spalling of refractories. Of the refractories in common use, silica is the most subject to spalling, and it is the only refractory considered here. E.H.McC.

Zircon raw materials for the refractory industry. G. PIRUMOV. *Ogneupory*, **5** [2] 134–38 (1937).—P. discusses the use of minerals containing zircon in the refractory industry. Large deposits of minerals containing from 7.59 to 24.79% zircon are found in the Ural mountains. M.V.C.

BOOKLETS AND BULLETIN

Petrography and heat treatment of chromite refractories. E. J. LAVINO & Co. Reviewed in *Steel*, **98**, 61 (April 27, 1936). H.E.S.

Refractories from a metallurgical viewpoint. E. J. LAVINO & Co. Reviewed in *Steel*, **98**, 61 (April 27, 1936). H.E.S.

Slagging action of Western Pennsylvania coals on different types of refractories in a small pulverized coal installation. C. R. FETTKE AND W. E. STEWART. *Carnegie Inst. Tech., Coöp. Bull., Mining & Met. Invest.*, No. 73, 90 pp. (1936). Price $1.00. The resistance of different types of refractories to slag erosion varies with the composition according to the tests described, the different types possessing the following relative order of increasing resistance: forsterite, silica, chromite, magnesia, high heat duty flint fire clay, super fire clay, intermediate mullite, high alumina (diaspore type), high alumina (electrically fused alumina type), high mullite (bonded type), cast mullite, and silicon carbide. The erosion of the refractories by coal ash is dependent on the ash composition and is related to the ash-softening temperature in that no erosion occurs until the temperature of the refractory face exceeds the ash-softening temperature. The higher the ash-softening temperature, the lower is erosion due to the coal ash. A critical erosion temperature, below which the ash has almost no erosive action on the refractory, exists for every coal ash and refractory; erosion does not start until the interfacial tensions are such that the molten ash wets the refractory surface. At this stage the solid phases of the coal ash have dissolved in the liquid phase leaving the liquid unsaturated relative to certain of the components of the refractory. The slag attack increases in direct proportion to increase in temperature after the critical temperature for a given refractory and ash has been passed. Above 2700°F there is a change in the temperature coefficient of erosion in the case of the aluminous silicate refractories. This is due to the 2813°F solidus line of the Al_2O_3-SiO_2 diagram being lowered by the iron of the slag to approximately 2710°F, so that above this temperature a change to mullite and liquid occurs with a subsequent weakening of structure and solution of the solid mullite phase by the liquid. The tests indicate that the mechanism of the slagging action is one of solution. The rate of diffusion was not a governing factor under conditions that prevailed in the experimental furnace. Diffusion should be considered, however, in cases in which no flame impingement occurs and the slag is relatively stagnant. Curves of different types of refractories are useful for predicting safe operating temperatures for furnaces constructed of any particular types of refractories utilizing coals of known ash-softening points.

PATENTS

Alumina production. JOSEF STÖHR AND ERICH REIDT. (Lonza Elektrizitätswerke und Chemische Fabriken Aktiengesellschaft (Gampel)). Can. 369,653, Nov. 2, 1937 (April 11, 1936). G.M.H.

Aluminum oxide separation. KARL H. S. LOFQUIST. Can. 369,555, Oct. 26, 1937 (Jan. 23, 1936). G.M.H.

Core for mold in which refractory material is cast. CORHART REFRACTORIES CO. Brit. 470,379, Aug. 25, 1937 (May 26, 1936).

Extraction of alumina from clay, kaolin, bauxite, etc. P. IPPERSIEL. Brit. 470,305, Aug. 25, 1937 (Sept. 21, 1935).

Furnace regenerator. A. R. KERNAN. U. S. 2,095,937, Oct. 12, 1937 (Sept. 24, 1936).

Hard burning diatomaceous earth. R. W. SCHMIDT (Dicalite Co.). U. S. 2,098,762, Nov. 9, 1937 (Dec. 12, 1935). The method of producing a superwhite calcined diatomaceous earth comprises calcining the earth with from 1 to 7% by weight of a water-soluble salt of an alkali metal to a temperature not below 2000°F and preventing material fritting of the earth by the addition thereto of an oxide of a metal selected from the group consisting of calcium, magnesium, and barium in quantity substantially equal to that of the alkali-metal salt.

Industrial production of alumina powder. SIEMENS & HALSKE AKT.-GES. Brit. 471,835, Sept. 22, 1937 (Nov. 30, 1935).

Magnesium oxide products and process of making. J. A. HEANY (E. J. Brennan). U. S. 2,095,982, Oct. 19, 1937 (July 26, 1934). The method for producing a dense, nonporous, vitreous, strong, pseudo noncrystalline refractory body of finely divided magnesia includes the steps of admixing magnesium oxide and a slightly acid oxide, with the quantity of the acid oxide being very small as compared to the quantity of the magnesium oxide, and heating it to a temperature between 1400 and 1600°C, the magnesium oxide constituting between 80 and 98% of the mix.

Producing ceramic articles which resist spalling. MAGNESITAL GES. Brit. 473,834, Nov. 3, 1937 (March 19, 1935).

Producing kyanite. J. H. WEIS (Feldspathic Research Corp). U. S. 2,094,440, Sept. 28, 1937 (June 16, 1936). Process of producing kyanite of definite predetermined composition comprises reducing kyanite ore to a granular condition such that the kyanite crystals separate from the remaining minerals, discarding particles of material smaller than about −60-mesh, sizing the remaining granular material into separate batches each containing particles of substantially the same grain size, subjecting the sized batches of material to the action of an acid containing a fluorine radical and then to an electrostatic field to remove quartz, subjecting the treated material to a high intensity electromagnetic field to remove magnetic impurities, storing the concentrated kyanite in a plurality of bins, analyzing the contents of the various bins, and blending the contents of the bins to produce a mix of uniform composition.

Refractories. NON-METALLIC MINERALS, INC. Fr. 808,862, Feb. 17, 1937; *Chem. Abs.*, **31**, 6435 (1937).—Refractories are made by heating materials having a basis of MgO, CaO, and SiO_2 to obtain a silicate binder which contains Ca and Mg and which is both a union or hydraulic setting agent at a low temperature and a crystalline union agent at a high temperature. Thus a magnesian clay and dolomite in proportions to give about a 1.6:1 ratio between CaO and SiO_2 are ground, intimately mixed into a paste, molded in the form of blocks, dried, and calcined. The calcined blocks are hard and dense and

composed of periclase, merwinite, and Ca orthosilicate. Examples are given of the use of sedimentary magnesite and limestone or dolomite and serpentine and dolomite.

Refractory. C. W. SAXE (Norton Co.). Can. 369,656, Nov. 2, 1937 (Sept. 24, 1936; in U. S., Sept. 27, 1935). A refractory article comprises alumina grains bonded with a vitrified bond including a substantial portion of bentonite. G.M.H.

Refractory article manufacture. R. R. RIDGWAY AND B. L. BAILEY (Norton Co.). Can. 369,248, Oct. 12, 1937 (Sept. 22, 1936). A refractory article consisting of a one-component crystalline phase of alumina or other metal oxide is manufactured by heating under pressure to a temperature at which the metal oxide is not reactive with the mold to a detrimental extent. See *Ceram. Abs.*, **16** [11] 341 (1937). G.M.H.

Refractory body. A. R. WOOD (Pilkington Bros., Ltd.). Can. 368,401, Aug. 31, 1937 (Sept. 11, 1936). A body consisting essentially of mullite crystals in a glassy matrix is made by (1) adding at least 4% titanium dioxide to a mixture of alumina and silica and/or their compounds, a portion being in plastic form and the alumina-silica ratio in the mixture being between 2 and 4, and firing at a temperature below 1770°; (2) adding at least 5% of titanium dioxide to a similar mixture in which the alumina-silica ratio is between 2 and 3 and firing as described; and (3) making a body consisting of a grog as described and a binder approximately the same as the grog in composition. G.M.H.

Refractory body. A. R. WOOD (Pilkington Bros., Ltd.). Can. 368,402, Aug. 31, 1937 (Sept. 11, 1936). A body consisting essentially of corundum crystals in a glassy matrix is made by adding fluorspar, cryolite, lepidolite, sodium silicofluoride, magnesium fluoride or opal glass, or a mixture of any of these to a mixture of alumina and silica and/or their compounds, a portion being in plastic form and the alumina-silica ratio being at least 4, and firing at a temperature below 1630°. G.M.H.

Refractory body. A. R. WOOD (Pilkington Bros., Ltd.). Can. 368,403, Aug. 31, 1937 (Sept. 11, 1936). A body consisting essentially of mullite crystals in a glassy matrix is made by adding from 3 to 10% of fluorspar or other fluorine-containing material to a mixture of alumina and silica and/or their compounds, a portion of these being in plastic form, the alumina–silica ratio varying depending on the quantity of fluorspar, and firing at a temperature below 1770° depending on the quantity of fluorspar. G.M.H.

Refractory body and method of making. GENERAL MOTORS CORP. Brit. 472,110, Sept. 29, 1937 (Jan. 25, 1935).

Refractory brick. E. RICHARDSON. Brit. 471,373, Sept. 15, 1937 (March 6, 1936).

Refractory lining for shaft furnace. H. A. BRASSERT & CO., LTD., AND H. A. BRASSERT. Brit. 471,973, Sept. 29, 1937 (Feb. 14, 1936).

Refractory material. V. M. GOLDSCHMIDT. Brit. 474,038, Nov. 3, 1937 (Feb. 20, 1936).

Refractory material. J. D. SULLIVAN (Battelle Memorial Institute). U. S. 2,098,839, Nov. 9, 1937 (Sept. 28, 1934). An article of manufacture comprises magnesite grains bound together by hydrolysis of a cement formed of a ground stable clinker consisting chiefly of periclase, tricalcium silicate, and calcium ferrite or aluminate, which clinker has been fired at a temperature of about 2500°F or more for a period of time sufficient to render it stable against slaking and dusting.

Terra Cotta

Manufacture of salt-glazed stoneware pipes and fittings. A. COULHON. Translated in *Brit. Clayworker*, **46** [546] 214–15 (1937).—Difficulties to be expected in salt glazing and methods of avoiding them are discussed. The use of engobes and glazes instead of salt is dealt with, and some of the difficulties involved which do not arise with the salt glaze are pointed out. See this issue, p. 17. R.A.H.

Microscopic investigation of acid-stable ceramic bodies. I. T. KLEINBERG. *Ogneupory*, **5** [1] 30–32 (1937).—A microscopic study of grog and bonding material (after firing to 500, 800, and 1200°) used for acid-stable products is recommended as a supplement to chemical analysis. Examples are given. M.V.C.

STANDARD

Salt-Glazed Fireclay Pipes. British Standard Specification No. 540—1937 (revised Sept., 1937). BRITISH STANDARDS INST., London. No change has been made in the technical requirements of the 1934 specification, but level invert taper pipes, bends, and junctions, which were previously in specification No. 539 (*Ceram. Abs.*, **16** [10] 303 (1937)), are now included in No. 540. A.B.S.

PATENTS

Fuel-economizer brick for open fireplace grates. W. M. LLOYD. Brit. 472,703, Oct. 13, 1937 (April 15, 1936).

Insulating wall construction. J. H. BROOKS (Ludowici-Celadon Co.). U. S. 2,094,635, Oct. 5, 1937 (April 30, 1937). An insulating wall construction comprises studs disposed in spaced relation, sheathing carried by the studs, insulating bats positioned between the studs, and fastening means for holding the bats in position against the sheathing, the means being secured at their ends to the studs in position to overlie the joints between adjacent bats and engage the bats at opposite sides of the joints to thereby hold the bats in position and cover the joints between adjacent bats.

Roofing and building tile. T. A. BROWN AND D. A. JENKINS. Brit. 472,048, Sept. 29, 1937 (March 12, 1936).

Roofing tile. J. N. MACLEOD. Brit. 472,085, Sept. 29, 1937 (Aug. 12, 1936).

Tile. HENRY JANSEN (Janline Tile Co., Inc.). Can. 368,383, Aug. 31, 1937 (July 2, 1936). A hollow tile block provided with a long, zigzag recess to take a specially designed bendable nail as a securing means. G.M.H.

Whiteware

Experimental determination of factors causing strains in true hard-fire porcelain flatware and a practical means for their elimination in production. R. E. GOULD. *Jour. Amer. Ceram. Soc.*, **20** [12] 389–94 (1937).

Manufacture of bone china. D. EARDLEY. *Pottery & Glass Record*, **19** [10] 261–62 (1937).—The first patent for bone ash in china was granted to T. Frye of Bow in 1749 for use with glass or frit. In 1800, Spode, Jr., abandoned the use of frit, substituted china clay and Cornish stone (pegmatite), and so started the bone china industry. No definite chemical formula is applicable to bone china. The finely ground materials are weighed, made into a slip, magneted, and dewatered in filter presses to form a plastic paste. This is pugged and wedged before being thrown and turned, molded, or cast. The dried ware is placed with powdered alumina in saggers and fired at 1300°C, *i.e.*, to vitrification. The resulting biscuit is scoured, sand-papered, cleaned, and then glazed and refired at 1100° to 1150°C. There must be no "placing marks" on high-grade ware; this involves methods of placing which make the glost firing four times more costly than that for cheaper ware. A.B.S.

Manufacture of pottery. MASCHINENFABRIK PAUL SCHUSTER. *Eng. Progress*, **18** [8] 182 (1937).—Two automatic high-efficiency clay pressing and molding machines are illustrated. The output of one machine is said to equal that of 10 jolleys or jiggers. Only one pressure mold is required for each shape. The handling and drying of numerous plaster molds is avoided. Ware is trimmed automatically in the press. About 200,000 pieces of ware can be produced before the steel mold needs to be dressed. Up to 1800 pieces of ware per hour, depending on size, can be produced by one machine. The profile rotates in the pot and the pot rotates in the mold ensuring a uniform wall thickness in the finished article. J.L.G.

Question box. ANON. *Trans. Ceram. Soc.*, **35** [9] 412–26 (1936).—The following topics are discussed: (1) whirlers in earthenware, (2) glaze peeling after dipping, (3) control of glaze fineness, (4) specked dishes, and (5) casting *vs.* jiggering. *Ibid.*, [10] 427–36.—The following topics are discussed: (1) flint in wall-tile bodies, (2) warming of glaze slips, (3) the fault, "chittered edges," and (4) rubber-lined mill cylinders. R.H.H.P., JR.

Screening of slip and the use of cobalt stain. H. R. DICKEY. *Jour. Can. Ceram. Soc.*, **6**, 48–50 (1937).—D. points out troubles which may arise from faulty screening or lawning of slip, with particular reference to blue spots caused by the use of cobalt as a stain. Tests were carried out on the use of cobalt sulfate and cobalt carbonate as the stain. No vivid blue spots were produced experimentally, and no blue spots of any kind were produced except where the concentration of cobalt was considerably higher than that used commercially. This can perhaps be explained by the longer time factor involved in production. Soluble cobalt sulfate, however, does concentrate on or in certain particles in the body mix, and cobalt carbonate does so to a negligible extent. Cobalt sulfate is still being used as a stain, as the trouble has been practically eliminated since the screening has been checked more thoroughly; moreover, the preparation of cobalt carbonate is a much more complicated procedure than the use of cobalt sulfate. D. feels that cobalt carbonate is a more foolproof staining material than cobalt sulfate and that its use should be investigated by those having trouble with blue spots or edges on a fired body. J.G.P.

Spark plug 26 years in service. ANON. *Electrician*, **119** [7] 193 (1937).—A spark plug was recently removed from a 40 h.p. Austin car after 26 years' service, with no indication of present or future failure of any kind. Twenty thousand miles in a modern high-compression engine is equal to twenty years in a pre-war car. After that distance, the plugs should be replaced with a new set. H.K.R.

STANDARD AND BULLETIN

Colors for bathroom accessories. ANON. *Nat. Bur. Standards, Com. Standard, CS*63-38, Sept. 16, 1937. 8 pp. Free. The standard is effective for new production from Jan. 1, 1938. See "Proposed—," *Ceram. Abs.*, **16** [6] 167 (1937). R.A.H.

Lead Frits and Fritted Glazes. J. H. KOENIG. *Ohio State Univ. Eng. Expt. Sta. Bull.*, No. 95, 116 pp. (July, 1937).—The object was to produce a suitable lead frit for glazes in which the lead would be insoluble and therefore offer no hazard of poisoning to the workers handling it. Twenty-five commercial lead frits were tested for the amount of lead dissolved by 4% acetic acid. Fifty-four experimental frits were made and tested for viscosity, melting temperature, water solubility, and dilute acid solubility. Starting with lead oxides, alumina is most effective in decreasing solubility, followed in order by silica, zinc, barium, calcium, beryllium, titanium, and zirconium oxides and magnesium oxide, which is neutral. Boric oxide is most effective in increasing solubility, followed by potassium and sodium oxides. The use of two frits in making a glaze is recommended. The lead is combined with the more acid-resistant constituents in one frit, and the boric oxide and alkalis are added as a second frit. If only one frit is to be used, much alumina has to be added to compensate for the boric acid and alkalis. A natural mineral can be substituted for the second frit. Glazes using these frits were made up and tested for viscosity *vs.* temperature, thermal expansion, acid and alkali resistance, crazing resistance, thermal shock, impact value, spit out, texture, and scleroscope hardness. The glazes were of one standard formula except for small variations in a few. These glazes were tested in the laboratory and at seven whiteware plants. W.D.F.

PATENTS

Ceramic material. HANS PULFRICH (General Electric Co.). U. S. 2,098,812, Nov. 9, 1937 (Dec. 31, 1936). A sintered ceramic material which is substantially impenetrable by gases and is adapted to be fusion-welded to glass and to form a vacuum-tight seal therewith, the material having a coefficient of linear thermal expansion not substantially exceeding 130.10^{7} and including as one component an oxide of the group consisting of magnesium and beryllium, having as another component an oxide of the

group consisting of titanium and zirconium, the molecular ratio of the first-named component to the last-named component being at least about 1 to 1, and having as a third component a siliceous ceramic bonding agent. HANS PULFRICH (Canadian General Electric Co.). Can. 369,620, Nov. 2, 1937 (Oct. 17, 1935). Can. 369,623, Nov. 2, 1937 (Jan. 6, 1937). A shaped, vacuum-tight body consists essentially of the product of sintering together about 50 parts each by weight of magnesium and titanium oxides and about 12 parts of a bonding agent comprising mainly alkaline earth metal silicate. G.M.H.

Ceramic raw material and method of making. J. H. WEIS (Feldspathic Research Corp.). U. S. 2,094,439, Sept. 28, 1937 (May 22, 1936). A ceramic raw material for use as a substitute for English china clay in the manufacture of whiteware consists of a mixture of domestic kaolin and feldspathic flux, the mixture having about the following composition: silica 47 to 57, alumina 27 to 37, potash 0.2 to 4.0, and soda 0.2 to 3.0%.

Composite body. HANS PULFRICH (General Electric Co.). U. S. 2,098,811, Nov. 9, 1937 (July 16, 1935). A composite body comprises a glass member and a member composed of a ceramic material having as main components magnesium oxide and titanium oxide, the members being fusion-welded to one another.

Earthenware. PORZELLANFABRIK KAHLA (Werner Rath, inventor). Ger. 646,923, June 24, 1937; Cl. 80*b*. 12.10; *Chem. Abs.*, **31**, 6842 (1937).—Glazed products with a low coefficient of expansion are obtained by glazing and firing systems containing SiO_2 40 to 70, Al_2O_3 20 to 50, MgO 3 to 30, and K_2O or Na_2O 2 to 20%. The MgO may be wholly or partly replaced by ZnO or BeO.

Sealed electrical connections for ceramic bodies. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 473,870, Nov. 3, 1937 (Feb. 29, 1936).

Spark plug. J. H. DOAK (H. S. Rupp and Anna Whitehead). U. S. 2,094,447, Sept. 28, 1937 (April 26, 1935; renewed March 1, 1937).

Spark plug. PIERRE FIGARD. Can. 368,438, Aug. 31, 1937 (Jan. 23, 1937). JAMES GRANT. Can. 369,694, Nov. 2, 1937 (Aug. 20, 1936). W. E. LETTERMAN. Can. 368,448, Aug. 31, 1937 (Sept. 4, 1936). H. RABEZZANA, T. G. MCDOUGAL, J. T. FORD, AND W. S. KIRK (General Motors Corp.). Can. 368,970, Sept. 28, 1937 (Oct. 14, 1936). See *Ceram. Abs.*, **16** [5] 155 (1937). G.M.H.

Spark plug insulator. A. H. FESSLER AND KARL SCHWARTZWALDER (General Motors Corp.). Can. 368,968, Sept. 28, 1937 (Sept. 24, 1936; in U. S., Nov. 8, 1935). T. G. MCDOUGAL, A. H. FESSLER, AND H. B. BARLETT (General Motors Corp.). Can. 368,969, Sept. 28, 1937 (Sept. 24, 1936; in U. S., Nov. 16, 1935). T. G. MCDOUGAL, A. H. FESSLER, AND KARL SCHWARTZWALDER (General Motors Corp.). Can. 368,967, Sept. 28, 1937 (Sept. 21, 1936; in U. S., Nov. 16, 1935). G.M.H.

Strain insulator. L. J. STEVENS (Locke Insulator Corp.). U. S. 2,093,875, Sept. 21, 1937 (Dec. 10, 1934).

Equipment and Apparatus

Application of technical X-ray irradiation. E. A. W. MÜLLER. *Siemens-Z.*, **17** [8] 449–54 (1937).—Practical methods and equipment for examination of materials, castings, and welds are described. M.H.

Applications of X-rays to industrial problems. J. R. TOWNSEND AND L. E. ABBOTT. *Metal Progress*, **29** [2] 64–70 (1936). F.P.P.

Automatic machine mold tamps 1920 brick per hour. W. E. DUNN MFG. CO. *Steel*, **98**, 52 (Feb. 3, 1936).—The machine is assembled on a fabricated frame of electrically welded steel angles and channels. Brick are formed in a continuous belt of steel mold-box compartments. This belt passes under a hopper from which the material is fed to the mold boxes which pass under a graduated packer head consisting of a series of tamper and trowel arms. This tamping and troweling mechanism is provided with specially designed roller bearings, each one with a dustproof cover and an extra large grease reservoir. The machine is operated by a 2-h.p. motor which transmits its power through an automotive-type disk clutch connected directly to the belt pulley. Driven directly from the pulley shaft is the worm-gear drive, running in an oil bath, dustproof gear housing. The continuous chain of mold boxes is driven by spiral tooth, beveled gears of nickel steel. These gears are directly driven from the worm-gear shaft. H.E.S.

Automatic temperature regulator for brick driers. S. MAKARIN. *Stroitel. Materialy*, **1937**, No. 4–5, pp. 46–48. P.B. & E.S.

Barrel finishing of metal products: IX. H. LEROY BEAVER. *Products Finishing*, **2** [1] 56–61 (1937).—The use of compressed air in connection with this operation is described. H.K.R.

Calyx drilling. V. TRIPP. *Excavating Engr.*, **31**, 520–22 (1937).—Calyx drills operate with chilled steel shot and water and cut cores 36 in. in diameter. The cores are broken loose with a wedge and lifted with an eyebolt or a sling. These particular machines did not drill over 92 ft. deep, but another type has gone to 1129 ft. The cost of drilling varied from $18 to $31 a foot. These large cores are far superior to a diamond-drill core for inspecting a formation. W.D.F.

Change of electrical resistance of iron-chromium-aluminium heating elements for temperatures up to 1300°C. E. SCHOENE. *Elektrowärme*, **7** [10] 220–26 (1937).—The dependence of the electrical resistance of Fe-Cr-Al heating elements on temperature and change with time was established up to 1300°C. The oxide formation at high temperatures on the surface begins with the formation of a continuous Al_2O_3 layer which exists for some time; other oxides break through this protecting layer, and finally the whole surface is covered with the other oxides. Coarse grain is formed during formation of the layer which remains until the surface is covered with oxides, when the grain disintegrates. Illustrated with curves and tables. M.H.

Comparison of low *versus* high discharge for ball mills. E. L. LONGMORE AND HOLLINGER MILL STAFF. *Trans. Can. Inst. Mining & Met.* (in *Can. Mining & Met. Bull.*, No. 298), **40**, 85–109; (in *ibid.*, No. 303), pp. 325–32; *Bull. Inst. Mining & Met.*, No. 389, 23 pp.; No. 390, 1–16; No. 392, 23–30; No. 395, 1–6 (1937).—At slightly lower power

consumption and at lower overall costs per ton, a low discharge mill will grind more tons of ore to a given fineness than will a high-discharge mill of the same type. A mill $6^1/_2$ ft. in diameter and $14^1/_2$ ft. long will grind 93.3% of the tonnage that two mills of the same diameter but half the length will grind. Maximum economy and capacity were obtained at 80% of critical speed and a ball load of 50% of mill volume. Classification and raking capacity equivalent to a 12- x 27-ft., 4-rake classifier of the Dorr FX type are required for economical operation of a $6^1/_2$- x $14^1/_2$-ft. low-discharge ball mill. Total costs of breaking and grinding to mill-feed size were 17.62¢/ton. A.H.E.

Compressed air for conveying and compressing foundry sands. F. ROLFF. *Giesserei*, **24** [15] 368–71 (1937).—The special arrangements necessary to keep the sand together and dense when used in sandblasting apparatus, molding machines, or on conveyers are described and critically reviewed. M.H.

Copper-lead bearings from metal powder. ERICH FETZ. *Metals & Alloys*, **8** [9] 257–60 (1937).—Cu-Pb bearings of very high Pb content are prepared by chemically coating Pb powder with Cu, pressing the Cu-coated powder into strips, sintering in a hydrogen atmosphere, and bonding onto a metallic carrier. The sintered strip may then be bonded to a steel backing using an intermediate layer of tin. Composite bearings and Pb-soaked Cu sponge, made from powdered metal, are described. F.P.P.

Correction of aniseikonia with ophthalmic lenses. K. N. OGLE. *Jour. Optical Soc. Amer.*, **26**, 323–37 (1936).—Aniseikonia is defined as an anomaly of the binocular visual apparatus in which a difference or incongruity exists between the size or shape of the ocular images of the two eyes. O. describes fundamental concepts regarding the correction of both ametropia and aniseikonia with lenses. A.P.

Determining coherence of silica masses and their readiness for molding. S. L. GERMAN. *Zavodskaya Lab.*, **6** [3] 351–56 (1937).—Small rods of a definite shape made of the mass tested are put in an even, progressive motion in the horizontal plane until the hanging part of the rod breaks off. The bending strength is determined by the weight of the pieces broken off. The coherence of masses determined by this method increases with increase in the time of working up with pans, attaining a certain maximal value, after which a tendency to decrease is observed. At the same time, the crushing strength of green brick becomes greater and the water absorption and porosity of both green and fired brick decrease. P.B. & E.S.

Drying processes and methods of drying refractory materials. A. A. SHUMILIN AND I. I. PALEEV. *Ogneupory*, **5** [1] 13–24 (1937).—The drying conditions of bodies of similar geometrical shape can be determined according to the principles of "similarity." Bodies containing water can withstand only a certain temperature without breaking. This temperature is called "critical" temperature. It depends on the moisture content of the body, its nature, and the mix. This critical temperature was lowered by adding finely grained grog to the materials tested. M.V.C.

"Electric eye" in industrial process control. R. A. POWERS. *Steel*, **98**, 40–43 (March 2, 1936).—Many industrial applications of the photoelectric cell or "electric eye" are illustrated and described. H.E.S.

Electric furnace. H. O. SWOBODA, INC. *Steel*, **98**, 63 (June 1, 1936).—A high-temperature muffle furnace with a capacity of 6 kw. is described and illustrated. The inside dimensions are 9 x 6 x 13 in. The furnace is suitable for operating temperatures up to 2300°F and is equipped with high-temperature metallic heating elements mounted in the hearth, side walls, roof, and rear of the furnace. The elements are of the wound type, substantially mounted in grooved refractories. H.E.S.

Electric furnaces. H. E. TRENT CO. *Steel*, **98**, 62 (March 23, 1936).—A new design furnace, 14 kw., 230 volts, single phase, and capable of working to a temperature of 1850°F, is described and illustrated. The inside dimensions are 12 in. wide, 9 in. high, and 24 in. long. The unit is equipped with a folded and formed heating element on all four walls. A foot treadle lifts the door, and an automatic release is provided to close the door when the occasion arises. H.E.S.

Electrostatic separation. Latest methods for coke-oven gas. ANON. *Engr. of India*, **5** [3] 67 (1937).—The principle of the electrostatic method of dust separation from by-product coke-oven gas, originated by Oliver Lodge, is described briefly. A.P.S.

Fundamentals of flotation. KELVIN SPROULE. *Can. Mining Jour.*, **57** [11] 582–88 (1936).—Flotation is a process in which gas bubbles, in rising to the surface of an aqueous suspension, attach particles of some minerals in an ore and concentrate them in the froth at the surface, other minerals remaining in the pulp. Frothing is a function of surface tension. Gas bubbles are introduced (1) usually by pneumatic means or by means of an immersed rotating impeller, (2) by precipitation of dissolved gas by reduction of pressure or by heating, or (3) by chemical reaction between ingredients. Selective attachment between bubbles and particles is a function of interphase energies of the system. If the surface energy of the liquid plus the energy of the liquid-solid intersurface is more than the surface energy of the solid, the liquid will tend to make a high contact angle with the solid, resulting in a minimum of wetting, and will tend to be displaced by the gas; the solid will tend to float with the gas to the surface. In the pneumatic machine the bubbles are relatively large, rise rapidly through the pulp, and form a froth several inches deep. In agitation machines the bubbles are smaller, rise more slowly to form a thin froth, and carry a heavier mineral load. The tendency to attachment or floatability varies with different minerals. Some minerals float without any treatment. Floatability can be varied by the addition of reagents that (1) make a nonwetted film on the surface of the minerals to be floated, or (2) regulate the effect of such reagents. Before flotation the ore must be ground to liberate the minerals to be floated, and it may be necessary to regrind the concentrate for further separation. Generally, the less dense a mineral, the larger is the particle that can be floated. Flotation efficiency increases with fine grinding, but beyond 400- to 500-mesh, efficiency tends to decrease. An average feed is about 90% through 100-mesh, of which 30% is −500-mesh. G.M.H.

Furnace draft controller. BAILEY METER CO. *Steel*,

98, 82 (March 2, 1936).—A complete self-contained furnace draft controller is described and illustrated. H.E.S.

Heat-treatment of wear-resistant gray cast iron. R. HANEL. *Giesserei*, **24** [7] 149–53 (1937).—Cast Fe is heat-treated either to reduce its hardness (by annealing at comparatively low temperatures) or to increase its hardness to obtain better wearing properties. The effect of structure and amount of graphite and martensite on wear resistance is discussed. Martensite gives to gray Fe good wearing qualities; the theory is explained. Martensite can be produced by lowering the transformation point, Ac_1, by rapid cooling, by alloying, and by the formation of austenite by alloying and subsequent heat-treatment. The various methods are discussed. M.H.

Hot blast temperature controlled automatically. G. P. LONERGAN. *Steel*, **98,** 66–68 (March 30, 1936). H.E.S.

Integrating micrometer for geometrical analysis of rocks. A. T. J. DOLLAR. *Mineralog. Mag.*, **24** [158] 577–94 (1937).—An integrating stage micrometer for the quantitative microscopic estimation of 1 to 6 kinds of constituents is described. The instrument has one thumb nut but six micrometer drums. It is designed to obviate wear caused by multiple screw threads. The stage micrometer (1) may be attached to the microscope without special fittings, (2) can measure and record constituents with an accuracy of 0.01 mm., (3) accommodates different types of object slides, (4) is light in weight, and (5) may be used for mineralogic, metallographic, or other types of specimens with either transmitted, reflected, or inclined illumination. H.I.

Lubrication of ball and roller bearings. H. T. MORTON. *Machinery* [N. Y.], **42,** 709–11 (1936).—Lubricant in a ball or roller bearing serves four distinct purposes: (1) it reduces the friction between the balls or rollers and the retainers to a minimum and minimizes other sliding friction in the bearing; (2) it acts as a covering for the bearing parts and prevents corrosion; (3) it acts as a medium for conducting away heat generated by the bearings; and (4) it effectively seals the bearing from the entrance of dirt, metal chips, water, dust, or other foreign matter. Fatty oils should be avoided since they become rancid and cause corrosion. Cleanliness is most important in handling greases. Factors inherent in a good grease are uniform quality, stability, absence of fillers, noncorrosiveness, no tendency to oxidation or gumming and hardening, and good temperature characteristics at both low and high temperatures. C.B.J.

Magnetic separation of quartz sand for melting glass. G. YU. ZHUKOVSKIĬ, S. V. RODIN, AND E. Z. ZHITOMIRSKAYA. *Keram. & Steklo*, **13** [7] 16–19 (1937).—An electromagnetic separator developed by the Institute of Glass is described. Tables and diagrams show the results of experiments. M.V.C.

Microscope and its application in mineralogic and geologic investigation. A. KARSTEN. *Zentr. Mineral. Geol.*, **1937A,** No. 2, pp. 50–57.—The new integral combinations of polarizing microscope and camera are described. See "Innovations—," *Ceram. Abs.*, **16** [10] 312 (1937). H.I.

Ni-Cr alloys for electric resistors. FRED P. PETERS. *Metal Progress*, **28** [4] 63–67 (1935).—The properties required of a material for electric resistor service and the extent to which available alloys possess them are discussed. Ni-Cr, because of better mechanical properties, is superior to recently developed Fe-Cr-Al alloys below 2100°F; above this temperature, Ni-Cr is relatively short-lived and the Fe-Cr-Al or Fe-Cr-Al-Co alloys must be used. F.P.P.

Optical specification of light-scattering materials. DEANE B. JUDD. *Jour. Research Nat. Bur. Standards*, 19 [3] 287–317 (1937); R.P. 1026. Price 10¢.—In 1931 Kubelka and Munk worked out the relation between reflectance and thickness of material for thin, homogeneous layers illuminated diffusely. In the equation expressing this relation, the hypothetical ideal material is defined by two constants, reflectivity and coefficient of scatter. J. concludes that the simple Kubelka-Munk theory applies to reflectance measurements of vitreous enamel, cold-water paint, paper, and dental silicate cements made on the usual reflectometers in the usual ways. Either no regular deviations of theory from actual measurements are found, or the deviations found are of about the order of magnitude of the experimental uncertainty. It is noted that the agreement between theory and experiment is as good for materials whose medium differs from air (vitreous enamel and dental silicate cement) as it is for materials having air as the medium (paper and cold-water paint). It seems, therefore, that corrections for light reflected from the inner side of the air-medium face are negligible. A description of these materials by means of the two constants of the theory, reflectivity and coefficient of scatter, is therefore of practical validity and use. The most valuable use of the methods described is to differentiate in a fundamental way between various members of the same group of materials. These methods also permit comparisons to be made between different classes of materials. Materials whose scattering elements are distributed in air have higher coefficients of scatter. Vitreous enamels have a much higher scatter than dental silicate cements; this corresponds to the different purposes of the two materials, the one to hide the ground coat with as thin a layer as possible, the other to match fairly translucent tooth enamel. The methods and graphical aids presented serve not only for the derivation of the fundamental constants of a light-scattering material according to the Kubelka-Munk theory but also for the reverse derivation, *viz.*, that of the reflectance and opacity of any thickness of the material of known constants. They also indicate the effect on reflectance and opacity produced by adding nonscattering dye or pigment. R.A.H.

"Owep" apparatus for determining electrically the humidity of clays and ceramic bodies. E. F. TESLENKO. *Zitein-Tech-SO*, Series 27, No. 2773, 13 pp.; abstracted in *Referat. Silikatliteratur*, **4** [7] 4249 (1937).—The method is based on the fact that in the interval between 3 to 20% water content, the electrical conductivity of ceramic bodies is proportional to their water content when the bodies have a constant porosity; this is obtained by subjecting the bodies to pressure of 4 to 5 kg./sq. cm. during the determination of conductivity. A brief description of the apparatus is given. M.V.C.

Photoelectric smoke penetrometer. A. S. G. HILL. *Jour. Sci. Instruments*, **14** [9] 296–303 (1937).—Require-

ments of a method for rapid determination of the efficiency of filters used for removing dusts from gases are discussed. A photoelectric photometric method for estimating the efficiency of filtering devices in terms of the percentage penetration of a standard testing cloud of carbon particles at a given rate of flow is described. Details of the apparatus and method of operation are given. Illustrated. J.L.G.

Porcelain tubes with lutes as stable protective casings for thermocouples. S. P. ZAMOTAEV AND S. M. BESEDIN. *Zavodskaya Lab.*, **6** [3] 377–79 (1937).—The tubes are covered with three layers of lutes: (1) 90% silicon carbide, 5% refractory clay, and 5% dextrin, all mixed with water; (2) 83% silicon carbide, 7% refractory clay, 10% dextrin and water; and (3) 20% refractory clay and 80% ground grog, mixed up with soluble glass with an addition of water. After drying, the tubes covered with these lutes can be fired at 1200° for 1 hr. P.B. & E.S.

Press accidents reduced by safety in die design. R. A. SHAW. *Steel*, **98**, 38 (Feb. 17, 1936).—Properly designed and constructed dies promote safety in the press shop. For large dies, chain slots and protecting guide pins are provided in drilling holes. For fastening small dies to press beds, slots or inlets are milled in the die edges to receive special clamps. The special clamps remain in place and can not move back and allow the top of the die to drop or to become loose, causing die wear and subsequent breakage. Medium-sized dies can be equipped with drilled lugs for bolting the dies to the top and bottom beds of presses. This eliminates the present method of using unsafe built-up clamps and saves much time. H.E.S.

Pyrometry. A. MOULD. *Foundry Trade Jour.*, **54** [1026] 304 (1936).—A new thermocouple of silicon carbide-carbon for temperatures up to 1800°C is described. It consists of a tube of compressed carbon with a rod of silicon carbide down the center. The two are joined at the hot junction end and insulated at the other end by means of a refractory ring. The advantages are the remarkable stability of the silicon carbide and carbon and the fact that high internal resistance galvanometers can be used. H.E.S.

Pyrometry—thermoelectric, optical, and radiation. KIRTLAND MARSH AND P. H. DIKE. *Metal Progress*, **30** [4] 167–70 (1936).—A review is presented of physical principles, structural fundamentals, and relative advantages of thermocouple, optical, and radiation pyrometers. Difficulties encountered in pyrometry are enumerated, and methods of locating and correcting them are suggested. F.P.P.

Relation of ball wear to power in grinding. FRED D. DEVANEY AND WILL H. COGHILL. *Eng. Mining Jour.*, **138** [7] 337–40 (1937).—Three sets of curves give data for the wear of steel rods, steel balls, and cast-iron balls in mills used for different ores. Pounds of ball material worn away per ton of ground material produced are indicated as well as pounds worn away per horsepower-hour. Skeleton screen analyses of feed and finished material are given, and the plant or material is mentioned. The authors conclude that ball wear for loads of equal weight is independent of ball size. Ball wear for equal power input is independent of the speed of the mill. Wear in terms of power varies less than wear in terms of tons of ore ground. For steel balls, average wear is 0.15 lb./h.p.-hr. If it exceeds this figure the ore is unusually abrasive. J.L.G.

Resistor alloy, chromium-aluminum-iron. S. L. HOYT. *Metal Progress*, **28** [1] 38–39 (1935).—The composition, properties, and uses of Smith Alloy No. 10 are given. The new material, an alloy of 37.5% Cr, 7.5% Al, and the remainder Fe, has longer life at 2300°F than Ni-Cr at 2100°F and may be used even up to 2500°F. F.P.P.

Rubber withstands sandstorm. B. F. GOODRICH CO. *Steel*, **98**, 54 (May 25, 1936).—Equipping the bed plate of a sandblasting machine for cleaning stove castings with a rubber cover has saved a stove manufacturer much time and money. H.E.S.

Rules for efficiency tests on dedusters. R. MELDAU. *Fachausschuss Staubtech., Ver. deut. Ing.*, Berlin, 1936. 29 pp.; *Chem. Abs.*, **31**, 6760 (1937).—Definitions of technical terms, abbreviations and units, and useful data, *e.g.*, the falling speeds of dust particles of various diameters and densities in air, are given. The procedure to be adopted in carrying out efficiency tests is discussed with reference to practical examples, *e.g.*, the electropurification of flue gases from a rotary cement kiln.

Sensitive hydrometer for determining small amounts of clay or colloids in soils. G. J. BOUYOUCOS. *Soil Sci.*, **44** [3] 245–47 (1937).—An especially sensitive hydrometer has a range of 1 to 10 g./liter and is graduated into 0.2-g. divisions. This soil hydrometer is heavy, has a large streamlined bulb, comes to equilibrium quickly, and is accurate, as shown by data in a table giving a comparison of the amounts of soil indicated by the hydrometer in soil suspensions with the amounts that were found experimentally by evaporating the soil suspensions to dryness and weighing the residue. Illustrated. See *Bull. Amer. Ceram. Soc.*, **14** [8] 259–62 (1935). G.R.S.

Simple electrical salinometer for estimating soluble salts in soils and irrigation waters. A. N. PURI AND BALMOKAND ANAND. *Soil Sci.*, **44** [3] 241–44 (1937).—A description is given of a simple type of electrical salinometer for estimating total solids in water and salt solutions. In principle it is a potentiometric method using large potential difference and a dip electrode made of copper and chromium plated. By using a high voltage the polarization e.m.f. is made small as compared to the potential difference across the electrodes. G.R.S.

Simple super-centrifuge for continuous treatment of liquids. E. J. JEFFERIES. *Jour. Sci. Instruments*, **14** [8] 282–83 (1937).—This powerful centrifuge was constructed to remove unfilterable impurities from large volumes of colloidal solutions. It is of the continuous type, treating as much as 5 liters of liquid per hour. As normally operated, the machine uses about 50 cu. ft. of free air per minute when supplied at a pressure of 100 lb./sq. in. Illustrated by a scaled drawing. J.L.G.

Small atmospheric furnaces for high melting temperatures. E. L. HARRIS. *Ind. Gas*, **15** [1] 9–10 (1936).—Various types of small furnaces heated by atmospheric gas burners are described. They are used for dental work, heat treating, carburizing, and melting metals such as lead, zinc, tin, type metal, and aluminum. Temperatures up to 2000°F can be attained. S.S.

Small cryptol laboratory furnace. V. A. LEBEDEV. *Zavodskaya Lab.*, 6 [3] 376–77 (1937). P.B. & E.S.

Specific surface of cement. W. HORNKE. *Cement & Lime Manuf.*, 10 [6] 173–81 (1937).—The two principal methods, air elutriation and sedimentation, are discussed, and the difficulties which they present are analyzed. Witte's method ("Color—," *Ceram. Abs.*, 15 [9] 280 (1936)) permits the measurement by optical methods of the surface of the powder, using a leukometer. Detailed descriptions of the theory and use of the instrument are given. G.R.S.

Sulfur boiling-point apparatus with internal electric heating. C. R. BARBER. *Jour. Sci. Instruments*, 14 [7] 227–29 (1937).—A sulfur boiling-point apparatus suitable for calibrating thermocouples is described. It is made of Pyrex brand glass with a platinum heater completely immersed in the sulfur. The platinum heater leads are sealed directly through the Pyrex brand glass below the surface of the sulfur. This method of heating reduces the risk of fracture of the container on remelting the sulfur. The boiling point (444.60°C) is realized to an accuracy of 0.1°C. Illustrated. J.L.G.

Thermax steels. B. WAESER. *Chem. App.*, 24 [17] 284–86 (1937).—Thermax steels are of ferritic-martensitic or ferritic-austenitic character and contain Cr; they can stand temperatures up to 1200°C in reducing and oxidizing furnace gases, up to 650°C as forged or rolled material in S-containing gases, and 1000°C in the cast state. The losses are between 2.5 and 5 g./in.²/hr. by scaling at 1100 to 1200°C. A table of physical properties for the six types of this material manufactured is appended. M.H.

Universal ore-polishing machine. F. C. PHILLIPS. *Mineralog. Mag.*, 24 [158] 595–600 (1937).—An ore-polishing machine provided with metal-surfaced laps is described. P. claims that the first cost is low and that it is flexible in operation. H.I.

Universal X-ray photogoniometer. R. B. HULL AND VICTOR HICKS. *Z. Krist.*, 96, 311–21 (1937).—An apparatus for making Laue, rotation, and Schiebold-Sauter photograms, without the intermediate transfer of the crystal, is described. A horizontal microscope mounted on the vertical goniometer axis may be used as an autocollimating telescope as well as for adjustment of the crystal and determination of interfacial angles. H.I.

Uses and limitations of the spectrograph for industrial control. THOMAS A. WRIGHT. *Metal Progress*, 29 [1] 53–57 (1936).—A general discussion is given of industrial spectrographic analysis, with a list of successful applications to date. F.P.P.

Wall friction in liquid agitation systems. ARTHUR W. HIXSON AND VALENTINE D. LEUDEKE. *Ind. Eng. Chem.*, 29 [8] 927–33 (1937).—The laws of fluid motion are studied in cylindrical agitation systems. The logarithmic plot of the friction drag *vs.* the Reynolds number is characteristic and is analogous to the case of a fluid flowing parallel to a flat plate. The relation between power input and stirrer speed, vessel diameter, liquid depth, stirrer depth, stirrer pitch, and fluid properties is given. Illustrated. F.G.H.

Wind tunnel as apparatus for deferrizing sands and their classification for abrasive purposes. G. YU. ZHUKOVSKIĬ AND E. Z. ZHITOMIRSKAYA. *Keram. & Steklo*, 13 [7] 19–22 (1937).—Deferrization of sand by wind sifting is based on the separation of smaller fractions which are usually more soiled by iron than the larger ones. Wind sifting is a simple operation and requires little consumption of electric energy. It is easy to classify sand according to absolute weight or grain size, if the material is homogeneous, in a horizontal wind tunnel. The smaller the fraction and the farther from the tube it is found, the more uniform is the granulometric composition obtained from the classification. The distance at which a fraction is found depends on the nature of the sand and is not the same for different types of sand. Repeated wind sifting increases homogeneity of the sand. M.V.C.

STANDARD

Portable Chemical Fire Extinguishers. British Standard Specification No. 740—1937. BRITISH STANDARDS INST., London. The specification relates to fire extinguishers of the foam and carbon tetrachloride type. The size, shape, nature of charge, size of nozzle, and mode of testing are specified. Each foam-type extinguisher must be capable of withstanding an internal hydraulic pressure of 350 lb./sq. in. for 5 min. It must be tested for $2^1/_2$ min. before being used. Every carbon tetrachloride-type extinguisher, except those in which the working does not exceed 50 lb./sq. in., must stand the same test. A.B.S.

PATENTS

Abrasive separating and cleaning apparatus. R. B. HUYETT (Pangborn Corp.). U. S. 2,003,446, Sept. 21, 1937 (Aug. 21, 1934).

Abrasive throwing machine. V. E. MINICH (American Foundry Equipment Co.). U. S. 20,538, Oct. 19, 1937 (Aug. 17, 1937); reissue of original 2,077,637, April 20, 1937. A wheel for throwing abrasive at blasting velocities comprises throwing blades extending from the periphery of a wheel substantially to the circumference of a normally stationary, centrally disposed, tubular control member having an abrasive discharge outlet in the tubular wall thereof, and movable abrasive ejecting means positioned interiorly of the tubular control member, the discharge outlet in the tubular control member being so shaped and arranged as to effect the gradual discharge of abrasive at a substantially uniform rate to the inner end of each throwing blade as it travels a single time through a predetermined limited arc of the circumference of the stationary control member, whereby each throwing blade is caused to receive gradually at its inner end each charge of abrasive and to discharge from the periphery of the wheel a substantially uniform stream of substantially uniform volume over a predetermined area.

Apparatus for manufacturing pottery ware. W. J. MILLER. Brit. 471,580, Sept. 22, 1937 (Feb. 3, 1936).

Ball mill. T. D. KENNEDY AND J. J. KEON (William Kennedy & Sons, Ltd.). Can. 368,387, Aug. 31, 1937 (Oct. 30, 1935). G.M.H.

Classification of material by elutriation. L. ANDREWS. Brit. 472,258, Oct. 6, 1937 (March 18, 1936).

Collection of dust from gases from cement kilns. J. S. FASTING. Brit. 473,847, Nov. 3, 1937 (April 20, 1936).

Dust and gases separating apparatus. TORLEIV SKAJAA (Det norske Aktieselskab for Elektrokemisk Industri). Can. 368,375, Aug. 31, 1937 (Sept. 19, 1935). G.M.H.

Filtration of solid bearing liquids. ARTHUR WRIGHT. U. S. 2,095,303, Oct. 12, 1937 (Oct. 6, 1934).

Firing clay, clay shale, etc. METALLGES. AKT.-GES. Brit. 472,215, Sept. 29, 1937 (Oct. 13, 1936).

Impact crusher. O. C. GRUENDER (Nordberg Mfg. Co.). Can. 368,983, Sept. 28, 1937 (Aug. 29, 1936; in U. S., Sept. 13, 1935). G.M.H.

Means for roughing or producing patterns on brick, clay columns, tile, etc. E. J. HOWARD AND C. DENNIS. Brit. 472,608, Oct. 6, 1937 (March 25, 1936).

Pulverizer. G. H. FRASER. Can. 368,865, Sept. 21, 1937 (Jan. 29, 1936). G.M.H.

Repress brick molding machines. R. T. L. SHORROCK AND MARSTON VALLEY BRICK CO., LTD. Brit. 472,477, Oct. 6, 1937 (March 19, 1936).

Screening apparatus. W. J. PARKS. Can. 369,164, Oct. 5, 1937 (July 24, 1936). G.M.H.

Water-sand blast gun. CLARENCE PLETCHER. Can. 369,425, Oct. 19, 1937 (Jan. 27, 1937). G.M.H.

Kilns, Furnaces, Fuels, and Combustion

Application of recirculating gas tube firing system to continuous decorating kilns. PHILIP DRESSLER. *Jour. Amer. Ceram. Soc.*, **20** [12] 383–88 (1937).

Coal for ceramic purposes. R. E. GILMORE. *Jour. Can. Ceram. Soc.*, **6**, 23–32 (1937).—G. outlines the activities of the National Committee on Coal of the National Association of Purchasing Agents, with special reference to ceramic products. The relative importance of the chemical and physical properties of coal for ceramic purposes is reviewed and general specifications are recommended for coal for this use. Analyses of typical American coals used in Canadian brick and tile plants are given, together with a discussion on the comparative values of Canadian coals for ceramic purposes. The general suitability of a coal for the particular clay used has, in the past, been the main factor in coal selection, since no two clays can be fired in exactly the same way. With a more detailed knowledge of the qualities of available coals it is often likely that, by careful selection, a more suitable coal can be located and introduced, not only to make a saving on the fuel cost but also to improve the quality of the ceramic product produced. The furnace designer, the kiln operator, the coal salesman, and the expert combustion (ceramic) engineer, by consulting with each other, could possibly effect improvements in ceramic firing by more careful coal selection. This would apply to the ceramic industry as a whole in Canada, to those plants that are looking for other products to manufacture with their present equipment, either on account of an exhausted local clay supply or a desire for expansion, and to those operators who contemplate the manufacture of finer products requiring a cleaner and better grade coal. J.G.P.

Efficiency of an electric furnace. R. W. D. *Verre & Silicates Ind.*, **8** [16] 188–90 (1937).—The efficiency of an electric furnace for a definite electrothermic operation is expressed by the ratio of the theoretical energy to be furnished to the effective energy consumed in relation to an equal weight of material. It may also be regarded as the ratio of the weight of the product obtained to that which should theoretically be obtained, these two weights being in relation to an equal quantity of energy and expressed for example in kg./kw.-hr. In general, the heating efficiency of electric furnaces is higher than that of fuel furnaces, but the heat loss from conduction, convection, and radiation is high and should be reduced to a minimum. The calculation of the thermal conduction is given; this permits the determination of the relative permeability of materials with regard to heat; the heat loss of a hot body is the sum of the loss by convection and that by radiation. Langmuir found that free convection can be considered as a conduction phenomenon through a gaseous pellicle of definite thickness. D. gives formulas by which the value of the loss by convection can be calculated if the thickness of the pellicle is known. The heat loss by radiation, unlike convection, is independent of the form of the body but depends on the nature of the surface of the body, its temperature, and that of the surrounding medium. Stefan found that loss by radiation is in proportion to the emissive power of the radiating body and to the difference between the fourth powers of the absolute temperatures of the body and the surrounding medium (formulas are given). The emissive power varies with the substance considered. Aluminum paint has a low emissive power and is used to coat the outside surface of metallic parts. The heat loss of a furnace in service can be determined by measuring as exactly as possible the mean temperature of the exterior surface of the furnace. The heat loss of the walls of an electric furnace can be determined by experiment and without any calculation, but it must be determined during a period when manufacturing is stopped, *i.e.*, when the glass is not being removed or the vitrifiable mix is not being charged into the furnace. At the moment when no chemical or physical work need be done (change in the state or heating of materials introduced into the furnace), the resistors constitute the source of heat, and the interior wall temperature of the apparatus can be measured by a pyrometer. If charging the furnace with the vitrifiable materials or withdrawing the glass is stopped, the temperature of the interior wall will rise progressively, then become stationary at a temperature t°C. As a result, the intensity of the current is regulated in such a way as to reëstablish the temperature of normal operation; when this becomes constant, the apparatus for electric measurement gives the power in watts absorbed by the resistor. This power represents exactly the flux of heat traversing the walls of the furnace; it also measures the heat loss, the furnace being in normal thermic operation. M.V.C.

Electric heat in the ceramic industry. J. L. BALLENY. *Jour. Can. Ceram. Soc.*, **6**, 9–16 (1937).—The ceramic trade generally has been slow to adopt electric heat for production purposes. A few applications of electric heat in firing processes are described. Electric heat can be utilized in many different ways, and each problem must be solved on its own merits. In the same industries are applications involving temperatures which may require from 200°F up to 2600°F, and for the majority of these, some type of electric heating will meet requirements. In the vitreous enameling industry, the material requires cleaning in hot water or

acid rinses before being sprayed. These tanks of water or of weak acid can be economically heated by immersion-type electric heating elements. Electricity has been efficiently applied in enameling plants in low-temperature drying ovens to dry the ware before firing. There are numerous applications of such low-temperature ovens which are heated most economically by electric elements. In glass annealing, where the time-temperature cycle is most important, electric heat in specially constructed glass leers is used extensively for stress relieving. In the ceramic field, other applications of electric heating include decorative firing, firing vitreous enamels, and, with special resistors, the firing of porcelain, china, floor and wall tile, etc. Advantages of electric firing include uniformity of firing; clean, odorless heat; longer life of furnaces; and low maintenance cost. In the production of fine ceramic ware, where the value of the material is high in proportion to its weight and in proportion to its firing cost, the field of application for electric heat is very promising. J.G.P.

Firing costs and utilization of kiln space with regard to an economical sagger size. HANS-JOACHIM LINDNER. *Ber. Deut. Keram. Ges.*, **17** [3] 149–63 (1936).—A mathematical and economic discussion of firing costs in an electrical porcelain factory, showing the effect of sagger size, fuel costs, etc., is presented. E.J.V.

Fuel economy in melting and reheating furnaces. R. J. SARJANT. *Iron & Steel Ind.*, **10** [13] 560–66 (1937).—S. discusses salient factors governing thermal performance and distinguishes between those factors of interest to the designer and those controllable in operation. A basis for comparing furnaces of similar character is the interrelation of thermal efficiency, ratio of heat absorbed by the charge to potential heat supplied by fuel, and heat utilized per unit area of heating surface. The heating surface is taken as the total area of brickwork in the empty furnace capable of receiving heat from hot gases. In insulated walls of different thicknesses, the time to reach the "steady" state varies from 12 to 18 hr. with $4^1/_2$ in. thickness of fire brick to 150 to 200 hr. with 18 in. thickness. The thickness of insulation has a relatively minor influence on the heat content of a composite wall when finally heated to a steady temperature. Illustrated. E.H.McC.

Fuel oils. F. F. MUSGRAVE. *Jour. Can. Ceram. Soc.*, **6**, 16–21 (1937).—Fuel oils are commonly petroleum products taken from selected portions of the original crude oil, to be burned in a variety of installations serving many diversified phases of industry. Formerly, "fuel oil" usually denoted a heavy dark product that was the residue after the more valuable constituents had been removed from the crude. Many different grades of fuel oil are now manufactured, but the heavier grades still have an important place in industrial work. Four general terms embrace all types of fuel oils made in the refinery: "natural," "cracked," "overhead," and "residual." M. defines these terms and lists the properties or characteristics which approximately govern the classification of fuel oils. He discusses the specifications drawn up by the National Research Council of Canada with regard to their relative importance and the manner in which the tests are carried out. Proper and efficient oil burning demands correct burner and furnace design for the type of fuel being used. The usual operating efficiency on oil-fired installations is about 75%. Oil burners increase the capacity of hand-fired coal systems and will, as a rule, equal the capacity of stokers and powdered coal. Fuel oils vary among themselves, and highest actual flame temperatures are obtained with those fuel oils which vaporize at lowest temperatures, atomize most readily, and burn at the highest rates. These conditions illustrate (1) why, in some installations, the lighter, lower viscosity, lower boiling range fuel oils often are more suitable and economical than the heavier grades, despite the increased unit cost, and (2) why capacity can sometimes be increased by the use of lighter grade fuel oil. Oil as a fuel has many advantages from the standpoints of adaptability to different uses, concentrated fuel values requiring a minimum of storage space, flexibility of handling and burning, and the furnace outputs and efficiencies which may be obtained. J.G.P.

Fundamentals of gas combustion. E. O. MATTOCKS. *Metal Progress*, **28** [4] 21–26 (1935).—M. reviews the factors affecting gas combustion in industrial furnaces, methods for evaluating flame efficiency, air and gas consumption, furnace heat losses, and features of furnace design. F.P.P.

Gas in the ceramic industry. O. FLOYD MADDUX. *Jour. Can. Ceram. Soc.*, **6**, 4–9 (1937).—Gas has been employed efficiently for drying and firing ceramic ware. Various types of kilns are discussed, with particular reference to the application of gas-burning equipment. The application of the surface combustion method of radiant heating in enameling furnaces has a number of advantages. In this process gas is efficiently burned in a continuous tube in a long, drawn-out, luminous flame. J.G.P.

High-temperature laboratory kiln. J. W. CRAIG. *Jour. Can. Ceram. Soc.*, **6**, 34–38 (1937).—A ceramic kiln for firing 30 brick at one time to cone 32 (3092°F) was constructed for the Magnesian Products Committee at the National Research Laboratories, Ottawa. To design a kiln firing super refractories at this high temperature, certain difficulties not encountered in the general run of laboratory kilns had to be overcome. To withstand the service conditions and to obtain the desired high temperatures, special attention was given to the selection of refractories and insulation. The kiln is periodic, downdraft, and direct fired. To permit effective insulation, it is placed off the floor on channels and retained on a welded pan with conventional angles and tie-rods. The roof thrust is taken up by channels which support the skews since such design permits rapid and ready replacement of the spring roof if desired. The burner ports are partially separated by independent partitions, and the flame then goes over a bag wall, through a slotted replaceable floor, and directly into the stack. In a year's operation the kiln has been idle only ten days. Forty-two firings were made, all in excess of cone 20, and four of them were made at cone 33. Nothing has been expended to date on maintenance. J.G.P.

Low-temperature carbonization of bituminous coal. DAVID BROWNLIE. *Ind. Eng. Chem.*, **29** [7] 734–41 (1937); see *Ceram. Abs.*, **16** [10] 296 (1937). F.G.H.

Mechanism for unloading brick from the Hoffman kiln. P. R. ZUBKOV. *Stroitel. Materialy*, **1937**, No. 4–5, pp. 45–46. P.B. & E.S.

Physics of firing. W. SCHUEN AND M. SCHUEN. *Tonind. Ztg.*, **61** [50] 554; [51] 569 (1937); *Trans. Ceram. Soc.*, **36**

[8] 67A (1937).—In the firing of ceramic products there are three danger points: elimination of the mechanically bound water at 100° to 150°, release of the chemically combined water at 500° to 600°, and occurrence of flashing at high temperatures. Heat transfer is effected by (1) conduction in gases at rest to a small degree, (2) convection and kinetic processes, and (3) radiation. Convection means heat transfer by moving gas particles. Radiation is heat transfer by the electrons of the atoms.

Possibilities of development in the construction of ceramic kilns. F. DETTMER. *Ber. Deut. Keram. Ges.*, **17** [2] 92–102 (1936).—D. points out how improvement in properties of present-day refractories makes possible the development of ceramic kilns which take advantage of the improved physical and chemical characteristics of the refractories. The better arrangement of flues, proportioning of the kiln chambers to increase the capacity of the kilns, and other constructional details are discussed. **Discussion.** FRANZ HAUTMANN. *Ibid.*, [3] 132–35.—H. discusses the possibilities of electric kilns for firing electrical porcelain, listing the types of heating elements available and costs and comparing fuel costs with gas. The ease of repair of electric kilns is described. E.J.V.

Primary liquefaction of coal by hydrogenation. Chemical nature and effectiveness of the vehicle. C. H. FISHER AND ABNER EISNER. *Ind. Eng. Chem.*, **29** [8] 939–45 (1937).—To obtain information on the relative effectiveness of various dispersion media in the primary liquefaction of coal by hydrogenation, Pittsburgh bed coal from the U. S. Bureau of Mines' experimental mine was hydrogenated in over thirty vehicles under comparatively mild conditions (400°C and 67 atmospheres original hydrogen pressure). Previous claims that tetrahydronaphthalene is a good dispersion medium were confirmed. Of the other hydrocarbons studied, only methylnaphthalene and diphenyl were of comparable effectiveness. Several completely aromatic (naphthalene and chrysene) and saturated hydrocarbons (decahydronaphthalene and *n*-hexadecane) proved to be poor vehicles. The presence of polar compounds, such as phenols and amines, in the vehicles was found to be beneficial. The products formed in highest yield were pitches, which melt at moderately elevated temperatures. Elementary analyses of these pitches indicated that hydrogenation had raised the carbon and hydrogen contents, lowered the sulfur and oxygen contents, and caused little change in the nitrogen content. F.G.H.

Refractory tunnel kiln. A. P. GREEN FIRE BRICK CO. *Steel*, **98**, 76 (March 2, 1936).—A new tunnel kiln which will add 10 million brick annually to the output of the company is under construction. The unit will have a continuous furnace section equivalent to 30 individual furnaces or "fire pockets." An elaborate system of control instruments in connection with advanced ideas in kiln designing will allow for the recovery of waste heat which will be used in twin tunnel driers operated in connection with the kiln. These driers are directly in front of the charging end of the kiln but are separate units. H.E.S.

Tunnel kiln and its suitability for firing material for construction. V. BODIN AND P. GAILLARD. *Brit. Clayworker*, **46** [546] 218–22 (1937).—The tunnel kiln, which in most cases appears suitable for the firing of goods for building purposes, presents the following advantages over the more usual kilns with traveling fires: (*a*) less space occupied; (*b*) more convenient arrangement for the rational movement of the goods, from the time of completion of drying up to their setting down in the stockyard or their loading up; (*c*) improved working conditions for men setting and drawing; (*d*) permanent installation of automatic stokers obviating the necessity of moving them as fire advances; (*e*) reduction of labor costs; (*f*) greater elasticity of production; (*g*) reduction of firing time by about one-half; and (*h*) more or less appreciable economy of fuel consumption. The disadvantages are as follows: (1) high cost of cars and their maintenance, (2) necessity for rigidity of construction of the rail track, (3) use of power for pushing the cars in the tunnel, (4) difficulty in obtaining complete uniformity of firing, and (5) danger of collapse of goods in tunnel, causing arrest of output and nullifying the advantages of this type of kiln. R.A.H.

Vaporization equilibrium constants in a crude oil-natural gas system. D. L. KATZ AND K. H. HACHMUTH. *Ind. Eng. Chem.*, **29** [9] 1072–77 (1937).—Data are presented in equilibrium constant charts which are useful in predicting vaporization phenomena. Descriptions of the apparatus used, analytical procedure, materials used, and equilibrium measurements are included. Illustrated. F.G.H.

BOOK, BULLETIN, AND STANDARD

Coal Seams of North Staffordshire: Ceramic Utilization. J. O'N. MILLOTT. H. M. Stationery Office, London, 1937. 49 pp., 2 charts. Price 1s 6d. M. gives a report on the local coal seams regarding their use in ceramic industries. He deals with eight seams and describes the structure of the coalfield. H.H.S.

Bibliography of U. S. Bureau of Mines Investigations on Coal and Its Products, 1910–1935. A. C. FIELDNER, ALDEN H. EMERY, AND M. W. VON BERNEWITZ. *U. S. Bur. Mines Tech. Paper*, No. 576. 145 pp. Price 5¢ from Supt. of Documents, Govt. Printing Office, Washington, D. C. R.A.H.

Sampling and Analysis of Coal and Coke. British Standard Specification No. 735—1937. BRITISH STANDARDS INST., London. This specification does not replace No. 420 or No. 496 for the buying and selling of coal and coke, but is intended to be used when making tests of plant performance. The methods specified are all well known, but the essential details are stated. A.B.S.

PATENTS

Furnace of brick and tile kilns or ovens. R. GREEN. Brit. 473,466, Oct. 27, 1937 (March 9, 1937).

Graphite resistor. R. E. GOULD. U. S. 2,095,977, Oct. 19, 1937 (July 27, 1936). Process of sealing a graphite resistor into a refractory protection tube using a carbon compound which forms carbon on pyrolysis comprises admitting the carbon compound into the space between the graphite resistor and the refractory protection tube, and heating the graphite resistor assembly to a sufficient temperature to effect a rapid pyrolysis of the carbon compound with the formation of carbon.

Kilns for ceramic material. FABRIQUE DE PORCELAINE LANGENTHAL SOC. ANON. Brit. 471,052, Sept. 8, 1937 (Jan. 21, 1935).

Method and apparatus for firing ceramic ware. E. J. HARRIS (Carborundum Co.). U. S. 2,097,620, Nov. 2, 1937 (Feb. 15, 1935). In an electrically heated furnace, a silicon carbide heating resistor and a gaseous jet for causing circulation of the gases within the furnace, the jet being so positioned as to tend to cause circulation in a direction opposite to that normally caused by convection.

Tunnel kiln. T. G. MCDOUGAL (General Motors Corp.). Can. 368,971, Sept. 28, 1937 (Nov. 2, 1936).

G.M.H.

Geology

Alteration of spodumene to kaolinite in the Etta Mine. G. M. SCHWARTZ. *Amer. Jour. Sci.*, **33**, 303–307 (1937).—In a limited portion of the mine, large crystals of spodumene have partially and, in some cases, completely altered to pseudomorphs of kaolinite. The identity of the kaolinite is checked by X-ray patterns. The crystals occur in a matrix of quartz. When removed in the mine they are wet and plastic, but when dried they form a hard mass which still shows the cleavage of spodumene. Analysis shows that during the process of alteration there is an almost complete loss of Li_2O, a large loss of SiO_2, and a gain in combined H_2O. J.B.A.

Attapulgus clay. PAUL F. KERR. *Amer. Mineralogist*, **22** [5] 534–50 (1937).—The identity and origin of the clay mineral in the fuller's earth from Attapulgus, Ga., has been studied. It is believed that the clay represents an accumulation of weathered montmorillonite derived from the crystalline rocks of the highlands. Data which have appeared recently in the literature concerning the creation of a new mineral species called "attapulgite" are not verified. F.J.Z.

Base exchange in soil separates and soil fractions (sand and silt). A. T. PERKINS AND H. H. KING. *Soil Sci.*, **42** [5] Pp. 323–26 (1936).—As particle size in soil separates decreases, base exchange capacity increases per unit weight but decreases per surface area. As particle size in soil fractions decreases, base exchange capacity of the 2.0 to 2.4 fraction remains constant but that of the 2.4 to 2.6 and 2.6+ fractions increases per unit surface area. G.R.S.

Ball clays and their uses. A. SCOTT. *Pottery & Glass Record*, **19** [10] 268 (1937).—There are 89 different brands of ball clays in England, all obtained in Devon and Dorset. In selecting ball clays, it is better to use several different types in the batch so that, should one vary, the total effect will be less than if only one clay is used. There is great scope for more research on ball clays. A.B.S.

Borax as an accessory material in ceramics and kernite as a raw material for modern production of borax and boric acid. HEINRICH MENZEL. *Ber. Deut. Keram. Ges.*, **17** [2] 103–10 (1936).—M. discusses the chemistry and physical properties of the various forms of borax minerals, the stability of the various hydrates of borax, and the production of borax and boric acid from the crude ores. E.J.V.

Ceramic concentrates resulting from the enrichment of pyritic schists from the Alexandro Nevski deposits. A. D. FEDOSEEV AND I. M. RAÏSKAÏA. *Mineral. Syr'e*, **11** [2] 42–46 (1936); abstracted in *Chimie & Industrie*, **37** [2] 300 (1937).—The concentrates studied have a low alumina content and high iron oxide content (6.66%); a high flux content diminishes refractoriness. The porosity is high but the plastic properties are satisfactory. As a ceramic raw material the argillaceous concentrates studied are of inferior quality. M.V.C.

Chemical composition of albite from Schmirn (Tyrol) as the plagioclase end-member. AGNES ENGELS. *Zentr. Mineral. Geol.*, **1937A**, No. 6, pp. 161–63.—Two chemical analyses of albite feldspar from Schmirn are given, the average of which in terms of feldspar components is 97.66 albite, 0.39 anorthite, and 1.95 microcline. This feldspar is therefore one of the purest natural albites. Previously published optical properties of this material are quoted. H.I.

Chemical composition of the alkali micas. PAUL NIGGLI. *Z. Krist.*, **96**, 89–106 (1937).—The three principal classes of the alkali micas (biotite, muscovite, and lithium mica) are subdivided on the basis of ratios of elements of different valence and coördination numbers. The hypothetical range of the three main classes is shown on a triangular diagram. Overlapping between classes is not believed to exist. H.I.

Chemical composition of clays, kaolins, etc., and their thermal resistance. RENATO MORETTI. *Centro Studi Ceram.*, **4** [1–2] 5–10 (1937).—M. summarizes the studies of the relations between the physical constants and chemical composition of clays, kaolins, etc., which have recently been made by scientists and gives the methods and formulas used. M.V.C.

Clay colloids as a cause of bedding in sedimentary rocks. W. D. KELLER. *Jour. Geol.*, **44**, 52–59 (1936).—A typical marine clay shale in thin section shows more than 80% of the particles oriented optically parallel. Bedding of clay shales appears to be due primarily to mass orientation of the particles. K. shows that colloidal clay soils upon desiccation give rise to platy crystalline aggregates having a high degree of orientation. Hence, lamination and bedding in shale may be developed in the colloidal fraction of the sediment, as well as in the coarser parts. The clay colloids of the experiments were derived from soils, the Putnam silt loam of northeast Missouri and the Davidson soil of North Carolina. The Putnam clay belongs to the montmorillonite-beidellite group and the Davidson soil tends to be lateritic. Particles larger than colloids could be formed far from shore by flocculation and then deposited as shale-producing material. Clay partings and films in limestone may have been derived from flocculated clay colloids. A.C.B.

Clays of the bleaching type. W. G. WORCESTER. *Jour. Can. Ceram. Soc.*, **6**, 65–69 (1937).—Worcester calls attention to the fact that the ceramists have paid little attention to bleaching clays. Fuller's earth at one time was the most widely used clay for bleaching purposes, but it has been superseded, for many purposes, by other bleaching clays, bentonite being among the more important. Bentonite is used both in its raw state and following an activa-

tion treatment. Chemically it has not been found possible to distinguish those clays possessing bleaching powers from those which are wholly lacking in them, though in general the bleaching clays carry a higher water content which is largely removed by heating to 200°C, whereas inactive clays do not give up the bulk of their water until 500°C where it is given up quickly. J.G.P.

Constitution and classification of the natural silicates. HARRY BERMAN. *Amer. Mineralogist*, **22** [5] 342–408 (1937).—Reëxamination of the constitution of silicates has become possible through X-ray structural studies, and as a result of this new method of attack, B. presents the evidence for the validity of the newer concepts and presents a more complete classification of the silicates, based on these newer concepts. B. gives a tabulated arrangement of the silicates according to the new classification, along with a lengthy discussion of the types and groups, a bibliography, and an index to the species discussed. F.J.Z.

Demonstrations in petrogenesis from Kiloran Bay, Colonsay: I, Transfusion of quartz. D. L. REYNOLDS. *Mineralog. Mag.*, **24** [155] 367–406 (1936).—The engulfment of quartz in hornblendite magma has resulted in the formation of alkali feldspar and quartz represented in veins of micropegmatite and syenite. The rocks developed do not represent a mixture of hornblendite and quartzite. They contain concentrations of Al_2O_3, K_2O, Na_2O, P_2O_5, S, NiO_2, BaO, and SrO. H.I.

Density of the pure potash feldspar constituent in microcline and the general chemical composition. E. ROTTENBACH. *Zentr. Mineral. Geol.*, **1936A**, 231–38.—Following the method of calculation of Chudoba (see "Densities—," *Ceram. Abs.*, **15** [5] 167 (1936)), the average density of the triclinic feldspar component of microcline was determined as 2.557$_9$. Plotting of the analyses of microcline given in the literature on a triangular diagram indicates that the triclinic feldspar microcline can scarcely be considered as a pure potash feldspar. H.I.

Disintegration and transformation of biotite. M. MEHMEL. *Chem. Erde*, **11**, 307–31 (1937).—Experiments in decomposition of biotite lead to the following conclusions: (1) Decomposition with acids produces "bleached" biotites, similar to those found abundantly in nature. The characteristic biotite lattice is destroyed. Amorphous silica is a residue of the treatment. (2) Decomposition with alkalis gives products with thin coatings of iron hydroxide like those observed in sediments. (3) Thermal decomposition is a transformation to biaxial biotite with a metallic luster. Methods are given for distinguishing biotite from other platy minerals, such as clays. H.I.

Disseminated kyanite. V. L. MATTSON. *Eng. Mining Jour.*, **138** [9] 45–46, 94 (1937).—M. describes in detail the process by which Celo Mines is working a deposit of kyanite disseminated through large masses of rock at Burnsville, N. C. The ore is 15% kyanite, 10% garnet, 30% mica, and 5% miscellaneous minerals. About 27% of the miscellaneous minerals are sulfides, mostly pyrrhotite with some pyrite, chalcopyrite galena, and sphalerite. They carry about 60 carats per ton in gold and silver. The remainder of the ore is quartz. Kyanite, mica, and garnet are separated as commercial products. Provision is made for calcining the kyanite if the purchaser wishes to pay for it. Most of the product is sold ground to 100-mesh or finer. About 35 men are employed. A complete flow sheet of the process is given. See *Bull. Amer. Ceram. Soc.*, **15** [9] 313 (1936). J.L.G.

Elementary examination of clays. ANON. *Brit. Clayworker*, **46** [546] 227–29 (1937).—Every clay should be tested for the presence of calcium and magnesium carbonates, the former because of its effect on the color of the fired product, the latter because of the danger of its crystallizing on the surface of the fired article. Fixed carbon in clays occurs frequently in coal measure deposits. It is not harmful up to 2 or 3%. Hygroscopic moisture and chemically combined water should be estimated. An insight into the behavior of clay in manufacture can be acquired by knowledge of its plasticity and shrinkage and how it behaves on firing both under reducing and oxidizing conditions. Methods to be followed in such examination are given in detail. R.A.H.

European and world zinc situation in 1936. O. W. ROSKILL. *Jour. Amer. Zinc Inst.*, Advance copy, 16 pp. (April, 1937); abstracted in *Bull. Brit. Non-Ferrous Metals Research Assn.*, No. 99, p. 9 (June, 1937).—The production of Zn (statistical and commercial aspects) is surveyed in detail in regard to Great Britain, Belgium, Germany, Poland, France, Italy, Yugoslavia, and the British Empire; its consumption, galvanization, and price are discussed.

Formation conditions of kaolin, montmorillonite, sericite, pyrophyllite, and analcite. W. NOLL. *Mineralog. Petrog. Mitt.*, **48** [3–4] 210–46 (1936).—From synthesis experiments in bombs under steam pressure with mixtures of Al_2O_3 and SiO_2 gels, N. concludes that (1) kaolin is formed at temperatures below and pyrophyllite at temperatures above 400°C in neutral, alkali-free, or acid solutions; and (2) montmorillonite is formed in alkali-rich solutions. Optimum concentrations in cations and OH ions for complete transformation to montmorillonite were found by experiment. The optimum concentration range for K, Na, and Ca for the formation of montmorillonite is considerably narrower than for Mg. Sericite is formed in potash-bearing alkaline systems at K_2O concentrations corresponding to its ideal composition. Zeolites, especially analcite, are formed in alkaline solutions at very high alkali concentrations. The parallelism between conditions of synthesis and natural origin is pointed out. See *Ceram. Abs.*, **16** [3] 99; [10] 310 (1937). H.I.

Formation of kaolin and silicification phenomena at Kutahya. WILHELM SALOMON-CALVI. *Yüksek Ziraat Enstitüsü. Akara* [Turkey], **28**, 1–5 (1936); abstracted in *Chem. Zentr.*, **1937**, **ii**, 1536.—A short geological description of the Killik region (Turkey), in which kaolin deposits are found, is given. There are young volcanic tuffs and silicified rock, probably old felsite porphyry. M.V.C.

Formation of laterite. D. W. BISHOPP. *Geol. Mag.*, **74**, 442–44 (1937).—In some cases rock weathering produces the hydrous oxides such as bauxite while in others it stops with the formation of kaolinite. B. discusses this phenomenon and suggests that vegetation may have some effect. W.D.F.

Geologic and technologic aspects of the sedimentary kaolins of Georgia. A. V. HENRY AND W. H. VAUGHAN. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 774, 11

pp. (1937); *Mining Tech.*, **1**, No. 1 (1937).—The kaolins occur in a belt diagonally across the middle of the state. They are of Eocene age, derived from the feldspathic rocks of the Piedmont Plateau and deposited in fresh-water deltas. There are soft, semihard, hard, and flint types. The mining is by open cut. These kaolins have a P.C.E. of 31 to 37. They are highly colloidal. Refining is done wet by washing and settling or dry by pulverizing in a hammer mill and air separation. Nonceramic uses predominate. They are used as fillers in paper, rubber, oilcloth, linoleum, paints, and pigments, and as coating clays for paper. Ceramic uses are in whiteware and refractories. W.D.F.

Identification of minerals in clays by X-ray diffraction. G. L. Clark, R. E. Grim, and W. F. Bradley. *Z. Krist.*, **96**, 322–24 (1937).—Composite flakes of dried, sedimented clays were X-rayed on a modified Bragg oscillating spectrograph. Many more orders of basal reflections can thus be obtained than by powder patterns. H.I.

Influence of hydrogen peroxide treatments on the exchange capacity of Maryland soils. J. B. Bartlett, R. W. Ruble, and R. P. Thomas. *Soil Sci.*, **44** [2] 123–38 (1937).—The purpose of this study was to estimate the amount of organic matter in the exchange complex of Maryland soils. The total exchange capacity was obtained by leaching with ammonium acetate and measuring the amount of ammonia absorbed. The organic matter was oxidized with 6% hydrogen peroxide. Total carbon determinations were made to measure the amount of organic matter in each soil before and after oxidation. Both the exchange capacity and organic matter were estimated before and after the treatment with hydrogen peroxide. The soils studied and results obtained were grouped according to their series and class within the five soil provinces. The coastal plain soils had the largest percentage of organic matter which was active in the exchange complex. The coarser or sandy classes in this group had the highest percentage of the total exchange capacity in the organic form. The percentage of organic matter taking part in the total exchange capacity was practically the same in the Piedmont and coastal plain soils. The finer textured soils in all the provinces, except the coastal plain soils, showed the greatest loss in exchange capacity by oxidation. The average value of the organic exchange complex obtained or, conversely, the amount of the complex destroyed by oxidation, was similar for the Appalachian and Mountain and Plateau, the Limestone Valleys and Uplands, and the River Terrace and Flood Plain soils. G.R.S.

Influence of potash-feldspar components on optical properties of plagioclase: II, Chemical and optical properties of the end-members, albite, anorthite, and microcline. Karl Chudoba and Agnes Engels. *Zentr. Mineral. Geol.*, **1937A**, No. 4, pp. 103–15.—New chemical analyses of albite from Rischuna-Alb, Switzerland, anorthite from Vesuvius, and microcline from the Silver Leaf Mine, Manitoba, and determinations of optical orientation and other optical properties are given. **III, Optical orientation of potash-bearing plagioclase.** *Ibid.*, No. 5, pp. 129–49.—Chemical analyses and optical orientations of 5 potash-bearing plagioclase feldspars are given. Comparison of optical properties of these feldspars with potash-free plagioclases fails to show the effect of the presence of the potash-feldspar component. For Part I see *Ceram. Abs.*, **14** [7] 171 (1935). H.I.

"Iron-rhodonite" (from slag) and pyroxmangite and their relation to rhodonite. Max Peruтz. *Mineralog. Mag.*, **24** [158] 573–76 (1937).—Unit cell and intensity data from Weissenberg diagrams are given for (1) an iron-rhodonite from iron slag, (2) natural pyroxmangite, and (3) natural rhodonite. The slag iron-rhodonite has the same structure as pyroxmangite but belongs to a different solid solution series from natural rhodonite. H.I.

Italian bentonite. H. T. Coss. *Centro Studi Ceram.*, **4** [1–2] 11–14 (1937).—A general review of the chemical and physical properties required of high-grade bentonite and of testing methods is given. Bentonite recently discovered at the island of Ponza is briefly discussed. M.V.C.

Le Chatelier. His significance for mineralogy and petrography. W. Kleber. *Zentr. Mineral. Geol.*, **1937A**, No. 2, pp. 57–59. H.I.

Leucite and pseudoleucite. N. L. Bowen and R. B. Ellestad. *Amer. Mineralogist*, **22** [5] 409–15 (1937).—Determinations upon leucites of contrasted occurrence show that the potash is replaceable by soda only to a very limited degree and that reaction with liquid magma is essential for development of pseudoleucite. F.J.Z.

Liquefaction and temporary thickening of clay slips. G. Keppeler and Hellmuth Schmidt. *Sprechsaal*, **70** [17] 221–22; [18] 235–37; [19] 247–50; [20] 259–62; [21] 270–71; [22] 285–86; [23] 297–99 (1937).—Clay slips from Zettlitz kaolin, Kärlich blue clay, one Na-bentonite, and two Ca-bentonites were studied with regard to their casting properties and thixotropy. Thixotropy means the reversible stiffening or thickening of the slip and is characterized by the flow pressure which increases to a maximum in course of time. The flow pressure represents pressure necessary to force the slip through a nozzle. The apparatus used is of simple construction. The slips were of the same viscosity. The OH concentration of ions is of the greatest importance. NaOH of different concentrations was added. It exerts a slightly peptizing effect in Kärlich blue clays and bentonites and increases considerably the flow pressure (slip thickening); however, it does not thicken the slip of Zettlitz kaolin. The peptizing effect of bases was increased in all materials, with the exception of Zettlitz kaolin, through the addition of "emulsifying agents." No thixotropic properties were detected in the Zettlitz kaolin concentrations used. Specific p_H values for the maximum of liquefaction and other specific values for the flow pressure, which did not depend on the reagents added, were found in every material studied. It must be noted that a coarse dispersed system is peptized to a maximum with a definite p_H value; with an increasing p_H, the peptizing effect disappears and changes into a thixotropic effect. Finally, the system changes and forms flakes with an increasing p_H. With an increasing p_H, the systems pass through the following stages: (*a*) coarse-dispersed, (*b*) peptized, (*c*) thixotropic, and (*d*) coagulated systems. The assumption that the crystal structure of the raw materials alone influences properties is not entirely correct. For instance, Kärlich

blue clay and kaolin have the same lattice structure, but their slips have different properties; Kärlich blue clay and bentonite have a different lattice structure, but their slips have the same properties. It seems that the "surface development" of materials is of great importance. That the "surface development" can be influenced by admixtures having specific properties can not be detected by X-rays. The proof for the effect of OH-ions and emulsifying agents was found by an artificial influencing of Zettlitz kaolin which originally showed no thixotropic properties. The thixotropic p_H range is determined by certain emulsifying agents. It can therefore be assumed that, with a sufficient colloidal content (surface development), thixotropic properties may be developed in each system by suitable admixtures. That OH ions are the chief agents for liquefaction has been proved with organic bases, such as piperidine and äthylamine, with which the same effects have been obtained. Tests showed that the press residue of the slip of maximum casting properties has the lowest water content. The results of the studies of Webb on the density of slips with the same water content were confirmed. Slips flowing with the greatest ease are those which have the lowest density, *i.e.*, the smallest "water casing" which envelops the clay particles, or those slips which possess relatively the greatest amount of freely flowing water. M.V.C.

Mineral lazulite and its types of deposit. H. Meixner. *Berg- & Hüttenmänn. Jahrbuch*, **85** [1] 1–22; [2] 33–49 (1937).—M. gives a complete treatise on the geographical, geological, stratigraphic, and chemical conditions of the deposits which occur in middle Europe, mainly in the Eastern Alps. The principal constituents, according to more recent determinations, are P_2O_5 35 to 42, Al_2O_3 29 to 42, FeO 1 to 4.5, MnO 0.01 to 0.13, MgO 8.6 to 11.8, CaO 0.15 to 8.2, H_2O^+ 5.5 to 6.0, SiO_2 3.6 to 14.2%, and sometimes K_2O, CuO, and TiO_2, according to origin. Color varies from light to dark blue. The origin and genetic history is discussed in connection with the surroundings of the deposits. Methods for analysis are described in detail; fusing with KOH gives the best results. The various modifications go under the names of lazulite, berlinite, trolleite, augelite, kirrolite, svanbergite, kyanite, westanite, pyrophyllite, and tetragophosphite. 130 references. M.H.

Mining and heavy industries in China. Anon. *Iron & Coal Trades Rev.*, **135** [3630] 508 (1937).—The assumedly vast mineral resources of China are discussed; they include (mostly in the north of China) coal, Fe, Sn, Sb, and W, which are already mined on a large scale, and Au, Ag, Cu, Pb, Zn, Mg, Mo, salt, gypsum, barytes, As, S, fire clay, talc, asbestos, kaolin, mica, fluorspar, crystal, graphite, and marble. Production and geographical statistics on coal, Fe and steel, and W are added. M.H.

Molybdenum and its compounds in the ceramic industry. Leon Demyb. *Argile*, No. 173, 7–11 (1937).—Molybdenum is found in nature in numerous complex but uncommon forms, such as molybdetrite, wulfenite, ilsemannite, molybdite, molybdurane, molybdoferrite, jordasite, molybdosodalite, etc. Molybdenite is the chief mineral of molybdenum. It is a sulfide, S_2Mo, which contains from 30 to 40% S and 55 to 59% Mo. Wulfenite or melinose is a natural molybdate of Pb, MoO4Pb. The alloys of Mo are of interest to ceramists. It is a white metal which is inalterable in air, melts at 2550°, and boils at 3350°C. It forms the following oxides: MoO, Mo_2O_3, MoO_2, Mo_2O_5, and MoO_3. MoO, Mo_2O_3, and MoO_3 are bases. Mo in the form of salts is a valuable reagent in chemical analysis. Mo and its compounds are also excellent catalyzers. The compound $PbMo_4O$ can be used as a yellow pigment. The compound MoO_4Ca does not melt or evaporate even at 1200°C. Silica has no effect on the "volalibility" of MoO_3; bright blues are obtained from it. In general, blue, yellow, red, and brown glazed potteries were obtained. M.V.C.

Nepheline syenites of Ontario. N. B. Davis. *Jour. Can. Ceram. Soc.*, **6**, 50–53 (1937).—In the Hastings-Haliburton area of central Ontario, the occurrence of nepheline syenites has been of considerable economic importance in the past, owing to the presence of the mineral corundum in certain phases of these rocks. In 1928, tests were made on syenite from the Blue Mountain in Methuen Township to determine the possibility of removing the small amount of iron-bearing minerals from the rock by magnetic separation. These tests were not quite satisfactory with the equipment available, but in 1929 a larger scale test made in the Ore Dressing Laboratories of the Mines Branch, Ottawa, demonstrated the feasibility of making a product satisfactory for use in glass manufacture. In 1935 a small test mill was erected at Lakefield, Ontario, by the Canadian Nepheline Co., Ltd., to use rock from the west end of Blue Mountain. The deposits on the east end of Blue Mountain were acquired by the Canadian Flint and Spar Co., Ltd. The small mill at Lakefield produced approximately 3500 tons of a granular product for the glass trade up to the end of 1936. Nepheline syenite is a general rock name designating a rock made up of feldspathic minerals (with no quartz present) and minor accessory minerals such as muscovite mica, biotite mica, hornblende, magnetite, etc. The amount of nepheline varies from a few per cent to as much as 90% in different deposits. Alumina in the syenite from the Canadian Nepheline Co.'s property is contributed mainly by feldspars, nepheline, and muscovite mica, whereas the syenite on the Canadian Flint and Spar Co.'s property obtains the alumina from the feldspars and nepheline, muscovite being practically absent. Both syenites, however, give similar chemical analyses. Other occurrences of nepheline syenite in Ontario are described. In 1935 the Ohio State University Engineering Experiment Station studied the use of nepheline syenite in ceramic ware (*Ceram. Abs.*, **16** [6] 180 (1937)). The high nepheline syenites offered the possibility of making better ware at a considerably lower firing temperature. As the available quantity of syenite of high nepheline content is very large and may be figured in millions of tons, it is therefore an important possible source of flux for the ceramic industry. J.G.P.

Paragenesis and color of fluorite in the English Pennines. Kingsley C. Dunham. *Amer. Mineralogist*, **22** [5] 468–78 (1937).—Details of the mode of occurrence and the results of a study of the distribution of colored varieties of fluorite in the northern Pennines are presented. F.J.Z.

Paragenesis of kyanite-amphibolites. C. E. Tilley. *Mineralog. Mag.*, **24** [158] 555–67 (1937).—T. reviews

analyses and characteristics of metamorphic rocks of the kyanite-amphibolite type with both sedimentary and igneous origin. H.I.

Paragenesis of kyanite-eclogites. C. E. TILLEY. *Mineralog. Mag.*, **24** [155] 422–32 (1936). H.I.

Pneumatolytic and hydrothermal alteration and synthesis of silicates. GEORGE W. MOREY AND EARL INGERSON. *Econ. Geol.*, **32** [5, Supp.] 607–761 (1937).—The study of the conditions of mineral formation has been carried out principally by the fusion method and the hydrothermal method. The majority of the work of the Geophysical Laboratory has been devoted to the study, by the fusion method, of silicate systems under their own vapor pressure, usually unappreciable. The operation of the hydrothermal method is explained and a bibliography of 156 references to hydrothermal alteration and synthesis of silicates is presented. Most of the papers listed chronicle only the synthesis of certain silicate minerals by heating their components with water in closed vessels at temperatures from the boiling point to above the critical temperature of water and at the pressure of water-vapor determined by the temperature, nature, and concentration. Each reference is accompanied by an abstract covering the materials used, the experimental procedure, and the results obtained (mineral product or products). Convenient author and mineral name indexes are appended. The bibliography covers 124 pages. Illustrated. J.L.G.

Pneumatolytic synthesis of silicates. C. J. VAN NIEWENBURG. *Chimie & Industrie*, **38** [2] 226–32 (1937).—Continuing studies of the solubility of quartz in supercritical water steam (*Ceram. Abs.*, **14** [6] 152 (1935)), N. describes the results of a series of experiments with the synthesis of various metallic silicates in an autoclave and gives the methods and apparatus used. Conclusions give a new conception regarding paragenesis of igneous rocks. Experiments with SiO_2 show clearly that it is possible to transport solid matter (which is not volatile) in supercritical water steam without requiring particularly high temperatures. M.V.C.

Possibilities of preparation of intergrown Hagendorf feldspar. G. GERTH AND BAUMGARTEN. *Ber. Deut. Keram. Ges.*, **17** [8] 391–94 (1936).—Near Hagendorf bei Waidhaus (Oberpfalz.) there is an occurrence of feldspar and quartz in large crystalline form under biotite and muscovite. By hand picking feldspar from the quartz it was possible to obtain an 85.3% feldspar, composed of 69.5% K-feldspar, 15.8% Na-feldspar, and 14.7% quartz. Due to different densities of the associated minerals, it is possible to obtain a white, spotless melting feldspar-quartz by use of a flotation method employing phenol and sodium oleate. By use of magnets, it is also possible to remove the magnetic minerals and produce a white, spotless melting product. The latter method is the cheaper. E.J.V.

Presence and distribution of boron in the potassium salts of Alsace. G. BERTRAND. *Compt. Rend.*, **205** [11] 473–76 (1937).—A thorough investigation of the chemical constitution of the K and Mg salts occurring in large quantities in Alsace revealed that, as in other maritime deposits, the clayey soils contain a considerably larger amount of B than the salt deposits; while the latter encloses about 1 to 2 g. B/ton of salt rock, the former contains more than 3 times that amount. Geological and geographica conditions are discussed. M.H.

Refractory clays from Krasnogorovka deposits. A. D. FEDOSEEV AND V. F. SAMOILOV. *Ogneupory*, **5** [4–5] 322–32 (1937).—The geology, mineralogy, and technical and chemical properties of Krasnogorovka clays (Northern Caucasus) and their classification are discussed. Conclusions regarding their use are given. M.V.C.

Research on national ceramic raw materials. Refractory clays. FAUSTO POZZI. *Corriere Ceram.*, **18** [4] 107–109 (1937).—The quality of a clay can be judged by fusion tests of cones of the clay, and the fusion point depends on the analytical ratio between the silica and alumina content and on the quantity of impurities of the clay. Iron oxide should not exceed 3%; titanium is not injurious unless present in large amounts and in company with iron; soluble sulfates are not harmful in small quantities, but insoluble sulfates are always injurious. The plasticity of a refractory clay is a very important factor in its evaluation; if a ball of clay 3 cm. in diameter resists deformation after 24 hr. immersion in water, its plasticity is very high. The ideal plastic clay should permit the incorporation of 70 to 80% thinning material without deformation. M.V.C.

Studies in silicate chemistry of the Geophysical Laboratory of the Carnegie Institution of Washington. G. W. MOREY. *Jour. Soc. Glass Tech.*, **20** [80] 245–56 (1936).—M. gives a brief account of the research work carried out during the past thirty years by the Geophysical Laboratory. The greater part of this deals with phase equilibrium relations in silicate systems. The results obtained on binary and ternary systems have been of great importance. It is pointed out that, when oxides of iron are present, oxygen must be considered a component, and in rock-forming systems water plays an important rôle. Twenty-nine references are given. C.J.P.

Technique of mineralography at Harvard. L. C. GRATON. *Amer. Mineralogist*, **22** [5] 491–516 (1937).—G. presents a summary of the techniques and methods employed at Harvard in the study of opaque minerals. F.J.Z.

Titanite and tilasite. Relation of the silicates to the phosphates and arsenates. HUGO STRUNZ. *Z. Krist.*, **96**, 7–14 (1937).—The crystal structure of tilasite, $(AsO_4$-F)MgCa, as deduced by Aminoff (*Kungl. Svenska Vet. Handl.*, **11**, 24 (1933)) is confirmed. Titanite and tilasite are shown to be isotypous. H.I.

Two new occurrences of pyrophyllite in the Alps. HEINZ MEIXNER. *Zentr. Mineral. Geol.*, **1937A**, No. 4, pp. 117–20. H.I.

Ukrainian clays and their fitness for the production of dry-pressed brick. V. S. NIKOLENKO. *Stroitel. Materialy*, **1937**, No. 4–5, pp. 42–44. P.B. & E.S.

Volcanic rocks resistant to corrosion of liquid acids. G. MALQUORI AND F. PENTA. *Ricerca Sci.*, [2] **7**, II [5–6] 335–38 (1936).—A series of volcanic rocks was treated with concentrated HCl and H_2SO_4. Minerals rich in silica were less affected by these acids than those with basic plagioclase. M.V.C.

Wollastonite solid solutions from Scawt Hill, County Antrim. C. E. TILLEY. *Mineralog. Mag.*, **24** [158] 569–72 (1937).—Data on the change in optical properties

with composition are given for a series of natural wollastonites, $CaSiO_3$–$FeSiO_3$, with $FeSiO_3$ as great as 25 wt.%. H.I.

World resources of aluminum ore. R. J. ANDERSON. *Mining Mag.*, **55**, 329–41 (1936).—Bauxite is almost the exclusive ore. It is of widespread occurrence, principally in semitropical or tropical regions, but economically valuable deposits are rather rare. Bauxite is classified as white or siliceous, titaniferous, and red or ferruginous. Analyses from producing mines show Al_2O_3 48 to 66, Fe_2O_3 1 to 26, SiO_2 1 to 27, TiO_2 1 to 9, and combined H_2O 10 to 31%. Different processes of extraction are used on different compositions. Much bauxite is used in the production of aluminum salts, abrasives, aluminous cements, and refractories. Total production in million metric tons was 2.1 in 1929, 1.0 in 1932, and 1.7 in 1935. The most important producing districts are Var, France; Arkansas, U. S. A.; Dutch Guiana; Gant, Hungary; Istria, Italy; British Guiana; Dalmatia, Jugoslavia; and Bintang, Dutch East Indies. Minor production comes from Australia, India, Germany, Greece, Ireland, Romania, Soviet Russia, and Spain. Unworked deposits are well scattered, some of the richest being in West Africa and India. Some of the estimated reserves in million tons are France 60, U. S. A. 25, Dutch Guiana 100, British Guiana 60, Hungary 140, Jugoslavia 80, India 30, Gold Coast 230, and Norway 30, totaling 964. This will supply the needs of the aluminum industry for 1000 years. Much work has been done on finding methods to use other aluminum-bearing rocks, but no other rock carries as much aluminum as bauxite, and these processes can not compete unless the supply of bauxite is cut off. W.D.F.

X-ray diffraction studies of two-micron fractions of some genetic soil profiles. G. L. CLARK, F. F. RUCKEN, AND D. H. REYNOLDS. *Z. Krist.*, **96**, 273–86 (1937).—Two-micron soil samples of several representative soil profiles of Saskatchewan, separated by a modification of the Robinson pipet method, were analyzed by means of X-ray powder patterns. Certain characteristic persistent lines in each of the reference patterns of biotite, muscovite, quartz, kaolinite, halloysite, and montmorillonite were used in identification. The relative abundance of different minerals in certain soil types and horizons is discussed. H.I.

BOOKS AND BULLETINS

Barium Minerals. J. SIMPSON. *Repts. Min. Ind., Imp. Inst.*, 84 pp. (1937). 2d ed. Price 2s. Reviewed in *Bull. Brit. Non-Ferrous Metals Research Assn.*, No. 99, p. 11 (June, 1937).

Chemistry of the anhydrous chlorides of chromium, a thermodynamic investigation. H. A. DOERNER. *U. S. Bur. Mines Tech. Paper*, No. 577. 51 pp. Price 10¢ from Supt. of Documents, Govt. Printing Office, Washington, D. C. D. presents part of a study undertaken by the Bureau to devise ways of utilizing the country's relatively low-grade chromite deposits. R.A.H.

Mineral composition and origin of Missouri flint and diaspore clays. VICTOR T. ALLEN. *Missouri Geol. Survey and Water Resources, 68th Biennial Rept.*, Appendix 4, 24 pp. (1935); abstracted in *Rev. géol.*, **16**, 607–608; *Chem. Abs.*, **31**, 6157 (1937).—The only commercial deposits of diaspore clay in North America are associated with flint clays which occur in sandstone-lined sink holes in the north Central Ozark region of Missouri. In addition to diaspore, minor amounts of gibbsite and the amorphous constituent of many bauxites, cliachite ($Al_2O_3 \cdot nH_2O$), have been identified. Petrographic and field evidence suggests that these Al hydrates were formed from the flint clays. Carbonate waters descended along fractures, aided by circulation in the porous sandstone rim. Colloidal SiO_2 was removed and Al_2O_3 concentrated along fractures.

Mineral Position of the British Empire. IMPERIAL INSTITUTE, London, 1937. 166 pp. Price 4s. Reviewed in *Bull. Brit. Non-Ferrous Metals Research Assn.*, No. 99, p. 24 (June, 1937).—The aim of this publication is to outline the status of the mineral (including metal) resources of the British Empire during 1935, the latest year for which statistics are generally available. The production of the more important metals and minerals in the Empire is compared with world production. The mineral and metal resources of each dominion, colony, protectorate, mandated territory, etc., are considered. Concise information of the position and extent of deposits of economic minerals is given, together with conditions prevailing at each deposit, *e.g.*, actual production and fluctuations, operating companies, quality of ore, etc. The metal and mineral trade of the larger areas is summarized in tables giving imports and exports and their sources or destinations.

Mineral raw materials. FOREIGN MINERALS DIVISION STAFF, U. S. BUREAU OF MINES. McGraw-Hill Book Co., Inc., New York. World supplies of mineral raw materials and the interdependence of nations for adequate industrial supplies of these materials are discussed. R.A.H.

Nature and Properties of Soils. College Text of Edaphology. T. LYTTLETON LYON AND HARRY O. BUCKMAN. Macmillan Co., New York, 1937. 3rd ed. 392 pp., 45 figs., 42 tables. Reviewed in *Soil Sci.*, **44** [3] 249 (1937). G.R.S.

Nonmetallic Mineral Resources of Eastern Oregon. B. N. MOORE. *U. S. Geol. Survey Bull.*, No. 875, 180 pp. Price 30¢ from Supt. of Documents, Govt. Printing Office, Washington, D. C. M. gives the results of an investigation of the nonmetallic mineral resources of eastern Oregon carried out in 1930 and 1931 by the U. S. Geological Survey in coöperation with the Oregon State Mining Board. Besides building stone and road material, which are abundant and widely distributed, the nonmetallic resources that offer possibilities of commercial production are asbestos, bentonite, clays, diatomite, limestone, pumice, and salines. Prospecting of clays and salines is warranted in the more accessible locations. Deposits of chrysotile asbestos may occur in the areas of serpentine rocks, but sizeable bodies of gypsum are not known. High-silica sand does not occur in this region, and it is believed that prospecting for glass sand would be useless. Fourteen deposits of diatomite and eleven deposits of limestone were found. R.A.H.

Strontium minerals. E. H. BEARD. *Repts. Min. Ind., Imp. Inst.*, 33 pp. (1937). 2d ed. Price 1s 6d. Reviewed in *Bull. Brit. Non-Ferrous Metals Research Assn.*, No. 99,

p. 10 (June, 1937).—B. discusses available Sr minerals; winning and treatment of Sr minerals and compounds and their uses; metallurgical uses of Sr metal, alloys, and minerals; and the availability of deposits of Sr minerals in various countries of the world. The celestite (strontium sulfate) deposits at Yate in Gloucestershire constitute in normal times almost the only economic deposit of this mineral in the world. Bibliography.

PATENT

Treatment of clay. ENGLISH CLAYS, LOVERING, POCHIN & CO., LTD., AND R. J. DAVIES. Brit. 471,554, Sept. 22, 1937 (March 17, 1936).

Chemistry and Physics

Analysis of doubly refracting materials with circularly and elliptically polarized light. R. D. MINDLIN. *Jour. Optical Soc. Amer.*, **27** [8] 288–91 (1937).—In the utilization of quarter-wave in polariscopic analysis, care must be taken that the retardations are accurately one-quarter wave or identical. Å.P.

Analysis of slags. S. N. SHKOTOVA. *Zavodskaya Lab.*, **6** [2] 231–33 (1937). P.B. & E.S.

Application of spectrographic methods to glass analysis. B. S. COOPER. *Jour. Soc. Glass Tech.*, **20** [81] 352–57 (1936).—The more useful applications of spectrographic analysis are briefly described. These include (1) qualitative analysis preliminary to chemical analysis, (2) testing the effectiveness of chemical separations, (3) testing the purity of batch materials, (4) determination of minor constituents, and (5) aids to the identification of glass inclusions. C.J.P.

Automatic determination of moisture in solid fuel and gases. V. A. NAKLONOV. *Zavodskaya Lab.*, **6** [2] 187–88 (1937).—The method is based on the formation of acetylene by the interaction of moisture contained in the gas with calcium carbide. P.B. & E.S.

Binary system FeO–Al_2O_3. A. B. M'INTOSH, J. R. RAIT, AND R. HAY. *Jour. Roy. Tech. Coll.* [Glasgow], **4** (Part 1), 72–76 (Jan., 1937).—A thermal diagram is constructed from thermal and microscope data. Two compounds were found which are provisionally assigned formulas of $3FeO \cdot Al_2O_3$ and $FeO \cdot Al_2O_3$. Both are characterized by strongly crystalline habit. The $3FeO \cdot Al_2O_3$ is formed from $FeO \cdot Al_2O_3$ and FeO at 1225°C by a very sluggish transformation. Photomicrographs are presented to show the structure of crystalline spinel material and the eutectic. Data on color, fluidity, surface tension, hardness, brittleness, crystal habit, and size are briefly discussed. W.H.B.

Birefringence of quartz in the far ultra-violet and the Schumann region. R. SERVANT. *Compt. Rend.*, **205** [3] 230–31 (1937).—The refractive indices were determined with wave-lengths from 2210 to 1454 Å. The birefringence increases in this range almost 100%. M.H.

Borax, boric acid, and their less known applications. A. L. CURTIS. *Sands, Clays & Minerals*, **3** [2] 115–18 (1937).—It is explained that borax is no longer refined from ulexite, colemanite, or pandermite but is obtained entirely from the American sources, rasorite (in Kern County, Calif.), $Na_2B_4O_7 \cdot H_2O$, mixed with clay and shale, and borax deposits at Trona, Calif., where it occurs together with Na and K salts in both the solid and liquid phases. It is obtained by solution and crystallization. B_2O_3 of 100% purity is obtained from the crystallized material by fractional crystallization. Besides extensive use in the glass, enamel, pottery, and leather industries, it is used in the manufacture of refractories as binders, *e.g.*, in fireclay brick a mixture of borax and boric acid in the ratio 1:4 is employed. For superficial lining of furnaces, 120 sand, 225 litharge, and 200 calcined borax is recommended; the mixture should fuse at 900° to 1000°C to be able to penetrate into brick linings. In the manufacture of artificial stone or marble, bonding agents of boric acid and dextrin or casein are used successfully in a composition of white cement, sand or marble dust, and a mineral color. No firing is required; this product is allowed to set for a few days and is then dried with hot air preparatory to working. Borax acts as accelerator in cements, about 0.4 to 2.0% being required; it replaces alum in this respect. For plasters in dental surgery, borax serves as retarding agent, a mixture of potassium sulfate 4%, alizarin sulfate 0.04%, and borax 0.4 to 1% being recommended. An excellent glaze formula for ceramic purposes is aluminum chloride 60, magnesium chloride 20, sodium chloride 10, and borax 10. Other applications for hard surfacing, incorporation in fuel briquets to reduce smoke production, and in electrolytic condensers are described. Eleven references. M.H.

Calcination of hydrated alumina. M.S. BELETZKII. *Legkie Metally*, **5** [2] 16–21 (1936); abstracted in *Chimie & Industrie*, **37** [2] 300 (1937).—During the calcination of hydrargillite, the structural water is eliminated at 225° and 500°. The monohydrate resulting from the dissociation of hydrargillite corresponds to boehmite. Gamma anhydrous alumina, which is obtained at 500°, is in a state of dispersion which causes its instability under ordinary conditions. The transformation of γ-alumina into α-alumina (corundum) takes place at 1220°. The following transformations are observed during calcination of hydrated alumina: hydrargillite-boehmite-γ-alumina-corundum. M.V.C.

Colorimetric determination of silica and phosphoric acid in aluminate solutions. W. J. TARTAKOVSKII. *Legkie Metally*, **5** [2] 7–15 (1936); abstracted in *Chem. Zentr.*, **1937**, ii, 444. M.V.C.

Colorimetric determination of silica in the presence of fluorine. W. J. TARTAKOVSKII. *Legkie Metally*, **5** [3] 24–32 (1936); abstracted in *Chem. Zentr.*, **1937**, ii, 444. M.V.C.

Colorimetric method for determining small quantities (maximum 0.1%) of iron oxide in raw materials and glass. L. SPRINGER. *Jour. Soc. Glass Tech.*, **20** [81] 319–23 (1936).—The methods used for solution of the sample are described, and the colorimetric analysis using potassium thiocyanate is explained. The standard iron solution, the comparison vessels, and the tests are discussed. A standard method is proposed which is said to be accurate to 0.001% maximum. C.J.P.

Crystal chemistry of simple silicates of the rare earths.

DAN GIUSCĂ. *Bul. Labor. Miner. gener. Univ. Bucuresti*, **1**, 27–37 (1935); abstracted in *Rev. géol.*, **16**, 488–89; *Chem. Abs.*, **31**, 6527 (1937).—Monosilicates (R_2SiO_4) were obtained in three structural types: (1) hexagonal (silicates of La, Nd, and Sm), (2) monoclinic (silicate of Sm), and (3) monoclinic (silicates of Y and probably Sc). Optical and X-ray data are given for each. Bisilicates were obtained in three types: (1) tetragonal (silicate of La, near its melting point), (2) monoclinic (silicates of La, Nd, and Sm with incongruent melting points), and (3) monoclinic (silicates of Sc and Y). Optical and X-ray data are given for each.

Crystal polymorphism. M. J. BUERGER AND M. C. BLOOM. *Z. Krist.*, **96**, 182–200 (1937).—A theory of crystal polymorphism is developed in which the physical states of a crystalline compound are considered as conditioned by the symmetry of the heat vibration modes. These are thought of in terms of the individual cluster vibration modes, the clusters being polyatomic vibration groups, such as coördination, ionic, and molecular groups in the crystal structure. The symmetry position occupied by the cluster in the structure is conditioned by the symmetry of the vibration mode. Since the various vibration modes have various kinetic energy capacities, those of increasing capacity are called forth as the compound traverses a field of increasing temperature. H.I.

Crystal structure of "beta alumina," $Na_2O{\cdot}11Al_2O_3$. C. A. BEEVERS AND M. A. S. ROSS. *Z. Krist.*, **97**, 59–66 (1937).—"Beta alumina" has been shown by chemical analysis ("Preparation—," *Ceram. Abs.*, **16** [7] 209 (1937)) and measurement of the unit cell and density ("Formula —," *ibid.*, **16** [8] 259 (1937)) to have the formula $Na_2O{\cdot}11Al_2O_3$. This paper gives intensity data and comparison of calculated and observed intensities for assumed positions of Na atoms in the structure. The unit cell and space group assigned by Bragg, Gottfried, and West (*ibid.*, **10** [8] 601 (1931)) are unchanged. $K_2O{\cdot}11Al_2O_3$ is isomorphous and identical in structure with $Na_2O{\cdot}11Al_2O_3$. H.I.

Darkening of some commercial titanium dioxide in daylight. W. O. WILLIAMSON. *Nature*, **140** [3536] 238–39 (1937).—During an investigation of the discoloration by light of ceramic glazes containing titanium compounds and of the later fading of discoloration when the glaze was kept in the dark, W. discovered that certain varieties of commercial TiO_2 are affected in a similar way. The specimens used passed from their normal creamy color to a deeper yellow-brown tint on exposure to light. The original color was restored in the dark. Among the explanations suggested are (1) oxidation of ferrous iron present in the titania to a more deeply colored ferric compound through photoactivation by the TiO_2, (2) change in state of oxidation of the titania (less likely), (3) change in the crystalline variety or grain size of the titania (improbable), and (4) alteration in the degree of dispersion of some colloidal material suspended in the titania. J.L.G.

Determination of alkali by the autoclave method. A. R. WOOD. *Jour. Soc. Glass Tech.*, **20** [81] 351 (1936).—The technique of this method was described in a previous paper (*Ceram. Abs.*, **14** [9] 213 (1935)). Routine alkali measurements have been made twice weekly for two years using specimens of soda-lime-silica and soda-lime-magnesia-silica glasses. The method is claimed to be very rapid and accurate to ±0.2%. C.J.P.

Determination of alkalis in silicates. V. F. VEPRITSKAYA AND M. L. GUREVICH. *Ogneupory*, **5** [4–5] 305–307 (1937).—In a series of rocks, alkalis were determined according to known methods. The method of Pukal, which has considerable advantages over those of Berzelius and Smith, is discussed in detail. M.V.C.

Determination of calcium and magnesium oxides. P. N. GRIGOR'EV. *Zavodskaya Lab.*, **6** [2] 238 (1937).—After the determination of sesquioxides, Ca is precipitated from the filtrate by the Richards method. The turbid mixture is heated for 2 hr. on a water bath. Drops of a 10% Na_2HPO_4 solution and 10 to 15 ml. of 10% NH_3 are added. To the cooled mixture are added 20 ml. of strong NH_3. The precipitate, consisting of $CaCO_3$ and $MgHPO_4$, is filtered through a glass filter and washed with 2.5% NH_3 to a complete disappearance of the reaction on oxalic and phosphoric acid. The precipitate is dissolved on the filter with hot 10% HNO_3. After washing, the liquid is heated to 70 to 80° and titrated with a 0.1 *N* $KMnO_4$ solution until a pink coloration appears. By multiplying the necessary amount of $KMnO_4$ by 0.0028, the amount of CaO by weight is obtained. The mixture, after partial evaporation and neutralization with ammonia, and with the addition of 10 ml. of NH_4NO_3, is boiled on an asbestos net, and 10 ml. of an ammonium molybdate solution are added. After another 5 ml. of the latter are added, the precipitate is filtered and washed with 1% HNO_3 and 1% KNO_3 and dried. The filter, with the precipitate, is put in a glass, and an excess of 0.1 *N* NaOH is added which dissolves the phosphoric-molybdenic complex. The excess of NaOH is titrated with 0.1 *N* HCl. Each milliliter of NaOH corresponds to 0.00031 g. of P_2O_5 or to 0.000261 g. of MgO. P.B. & E.S.

Determination of carbon in glasses colored by carbonaceous matter. K. FUWA. *Jour. Soc. Glass Tech.*, **20** [81] 333–37 (1936).—A modification of Nicloux's method (*Ind. Eng. Chem., Anal. Ed.*, **4**, 403 (1932)) for the determination of carbon is described. The effect of carbon content on the color of glass was investigated for a parent glass, SiO_2 72%, CaO 12%, and Na_2O 16%, when the carbon was added in the form of graphite, carbon black, and cane sugar, both without and in the presence of sodium nitrate. See *Ceram. Abs.*, **16** [3] 86 (1937). C.J.P.

Determination of cobalt: a new volumetric method. B. S. EVANS. *Analyst*, **62** [734] 363–77 (1937).—The precautions necessary to make the cyanide titration reliable and accurate are detailed. H.H.S.

Determination of ferrous oxide in rocks and minerals. V. SMIRNOV AND N. AIDINYAN. *Compt. Rend. Acad. Sci. U.R.S.S.*, [N.S.] **14** [6] 353–56 (1937).—A mixture of 0.5 g. finely powdered rock, 10 cc. of sulfuric acid (1 vol. of concentrated H_2SO_4 : 1 vol. of H_2O), and 40% of hydrochloric acid was placed in a small platinum basin and immediately covered by a layer of toluene or with a solution of paraffin in toluene. The mixture was heated, while being stirred with a platinum spattle, on a water bath until completely decomposed; after the completion of the reaction (in ¼ to 1 hr.), the mixture was poured out into 400 cc. of water, into which the basin was also put, and the ferrous oxide was titrated with $KMnO_4$ in the presence of boric acid. Paraffin can be used with toluene. P.B. & E.S.

Determination of iron in sands and glasses. A. R. Wood. *Jour. Soc. Glass Tech.*, **20** [81] 324–25 (1936).—The procedure is described. It involves dissolving the material to be tested in hydrofluoric acid, to which is added a little sulfuric acid, and evaporating the solution to dryness at 140° to 160°C. The residue is taken up with hydrochloric acid, bromine water is added to ensure oxidation, and, after removal of the free bromine, the iron is determined by titration with titanous chloride. C.J.P.

Determination of potassium as potassium silver cobaltinitrite. A. M. Ismail and H. F. Harwood. *Analyst*, **62** [735] 443–52 (1937).—Very suitable to the determination of K in clays and soils is the method of precipitation by the addition of Na cobaltinitrite to a K solution containing Ag ions. The precipitate is apparently a mixture in constant proportions of $KAg_2Co(NO_2)_6$ and $K_2AgCo(NO_2)_6$. H.H.S.

Determining SiO_2 in aluminate solution by rapid method. K. A. Vasil'ev. *Legkie Metally*, **4** [7] 52–53 (1935); abstracted in *Chem. Zentr.*, **1936, i**, 2398.—Silica is precipitated with gelatin at boiling heat from the aluminate solution acidified with H_2SO_4; the precipitate is filtered. The filtrate is treated with gelatin and ashed (incinerated), and the silica is weighed. M.V.C.

Equilibrium diagram of the ternary system Na_2SiO_3–$PbSiO_3$–SiO_2. K. A. Krakau, E. J. Mukhin, and M. S. Heinrich. *Compt. Rend. Acad. Sci. U.R.S.S.*, [N.S.] **14** [5] 281–85 (1937).—Evidence was found of the formation of five 3-component silicate compounds giving well-formed crystals besides the 2-component silicates $Na_2O \cdot SiO_2$, $Na_2O \cdot 2SiO_2$, and $PbO \cdot SiO_2$. These are as follows: $Na_2O \cdot 2PbO \cdot 4SiO_2$, $Na_2O \cdot 3PbO \cdot 6SiO_2$ (in two polymorphous modifications), $Na_2O \cdot 3PbO \cdot 6SiO_2$, $Na_2O \cdot 3PbO \cdot 7SiO_2$, and $3Na_2O \cdot 3PbO \cdot 11SiO_2$. The physical and crystallographic characteristics of these compounds and a description of crystallization fields of the system are given. See *Ceram. Abs.*, **16** [6] 188 (1937). P.B. & E.S.

Heat of dehydration of clays. A. S. Bazilevich. *Ogneupory*, **4** [2] 38–39 (1936).—The heat of dehydration of clays is composed of three values: (1) latent heat of evaporation of water, (2) heat carried away by evaporation of water (a function of mean temperature of dissociation), and (3) heat used to dissociate 1 molecule of the given hydrosilicate. The latter value is variable according to the chemical nature of the clay. M.V.C.

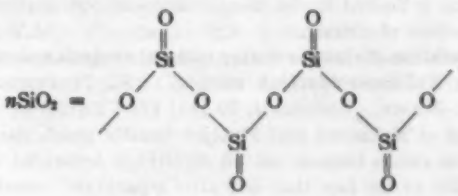
Index for the study of ceramic materials and soils. Antonio Barreto. *Rev. chim. ind.* [Rio de Janeiro], **6**, 144–46 (1937); *Chem. Abs.*, **31**, 6838 (1937).—The alcoholate index of clays and soils is determined as follows: 5 g. of the dry, finely pulverized material is treated with 50 ml. of MeOH or EtOH and shaken ½ hr. with 20 ml. of 0.5 *N* NaOH; the solution is filtered and an aliquot is diluted and titrated with 0.1 *N* H_2SO_4. The alcoholate index is expressed as milliliters of 0.1 *N*/100 g. of material and represents the amount of Na alcoholate insoluble in an excess of alcohol. Kaolins (after levigation) show alcoholate indices below 160; higher indices (307 to 496) indicate clays; the alcoholate indices of some Brazilian soils range from 332 to 865; in the Federal District the average is 450. In the examination of soils the preëxisting humus-hydrargillites are determined by treating a 10-g. sample with 20 ml. of 0.5 *N* NaOH without the addition of alcohol; the total alcoholate is then determined by the described procedure; the difference between the two results represents the content of acid clay. The reacting substance in this method is the molecular complex $[(O:SiO_2)_3Al]H$ which forms insoluble alcoholates. Being a measure of the decomposition of clays, this index can serve for controlling the composition of ceramic and cement mixtures, as it measures the content of combinable hydrargillite.

Influence of temperature on the Raman frequencies of topaz, beryl, and calcite. Theodore Kopcewitz. *Jour. Phys. Radium*, **8** [1] 6–10 (1937).—Raman spectra of topaz, beryl, and calcite were observed at different temperatures. The frequency in all cases dropped with rising temperature. The frequencies observed with calcite were identified as those previously noted by Schaefer and Schubert in the infra-red region. F.P.P.

Investigation of structures of silica glass, pozzuolanas, and clays by electron diffraction. N. A. Shishakov. *Compt. Rend. Acad. Sci. U.R.S.S.*, **15** [3] 127–30 (1937).—Diffraction patterns from crystallites present in silica glass, pozzuolanas, and clays were obtained by means of electron rays. The intensity distribution on these diagrams appeared very similar to that of high cristobalite, though some discrepancies were shown by Bragg's spacings. Similar observations were made with sand and silica brick (low cristobalite in these two cases); in tridymite, silica gels, and some opals no such rings were observed. Electronograms of different clays proved to be similar to those of pozzuolanas and vitreous silica. All these substances must consist of two-dimensional monocrystals. P.B. & E.S.

Laws of soil colloidal behavior: XX, Neutral salt effect and the amphoteric points of soils. Sante Mattson and Kwang-Chiung Hou. *Soil Sci.*, **44** [2] 151–66 (1937).—The equi-ionic point of a soil is that p_H of a solution which is not affected by the addition of the completely unsaturated soil (free acid-base ampholytoid). It represents the p_H at which the capacities of the soil to combine with the anions and the cations of the solution are equal. The p_H of exchange neutrality (in the author's experiments, the point of intersection of the titration curves in water and in the salt solution) is that point at which the addition of a neutral salt to a soil suspension does not affect the p_H of the latter. It represents the p_H at which the increments (produced by the salt) in the capacities of the soil to combine with the anions and the cations of the solution are equal, irrespective of the total capacities at this point. This complicated relationship is illustrated by curves. For Parts **XVIII–XIX** see *Ceram. Abs.*, **16** [9] 286 (1937). G.R.S.

Model of the polymerized molecule of silicic acid in the melt. G. G. Laemmlein. *Compt. Rend. Acad. Sci. U.R.S.S.*, [N.S.] **2** [4] 139–42 (1936).—The space models proposed by Sosman, Niggli, and Laves are critically reviewed. L. proposes an expanded version of Niggli's chain model as follows:



The infinite chain lies in the lattice in the direction [1213]. The hypothetical behavior of such chains in the processes of melting and solidifying is discussed. 5 references. P.B. & E.S.

Passage of helium at ordinary temperature through glasses, crystals, and organic materials. RAYLEIGH. *Proc. Roy. Soc.* [London], **A156**, 350–57 (1936).—Helium passes through silica glass at ordinary temperatures at a rate of 0.3 cu. mm./day/sq. cm., using a plate 1 mm. thick. Air does not pass to any sensible extent. Alty (*Ceram. Abs.*, **13** [6] 163 (1934)) and others have considered the process to consist in a creeping of the gas molecules along the walls of submicroscopic channels in the material. Ordinary glasses containing basic oxides do not transmit helium. It is shown that boron trioxide glass possesses the property, with a transmission rate of the same order as that through silica glass, while borax glass does not. Various single crystals have been tested, including beryl, which is known to have channels 2.6Å wide, parallel to the axis. No passage of helium was detected. The same applies to various light metals, magnesium, aluminium, zinc, and copper, in the form of sheets. Gelatin sheet transmits helium much more freely than air (factor 184), as do celluloid and cellophane to a lesser degree. The actual transmission of gelatin is greater than that of silica. An artificial channel, a few Ångstrom units wide, obtained by putting a plate on the end of a glass tube in optical contact, shows somewhat the same behavior. A.P.

Practical possibilities in spectrographic analysis. GEORGE R. HARRISON. *Metals & Alloys*, **7** [10] 290–96 (1936).—H. advocates greater use of the spectrograph because of its speed and actual economy. It is now possible to determine 70 elements spectrographically; H. believes the difficulties preventing determination of 20 others can be overcome by methods as yet undeveloped. The theoretical background of the subject, various systems and techniques, and certain practical experiences with spectrography are discussed. F.P.P.

Rational analysis of aluminous frits obtained by the lime and sodium carbonate process. K. A. VASIL'EV AND B. A. FAKTOROVICH. *Legkie Metally*, **5** [2] 1–6 (1936); abstracted in *Chimie & Industrie*, **37** [1] 103 (1937).—Research was carried out on the composition of products formed during the fritting of bauxite with limestone and sodium carbonate. Several samples were analyzed by (1) treatment with water, (2) treatment of residues left from washing with water with a caustic solution of 1% of alkali, (3) treatment of residues of the alkaline lixiviation with a solution of 20% citrate of ammonium, and (4) treatment of the residue resulting from the preceding operation with 10% HCl. The mineralogical analyses of the products and extracts obtained indicate the presence of (*a*) hydrated lime, (*b*) $5CaO \cdot 3Al_2O_3$, and (*c*) $SiO_2 \cdot H_2O$. The utilization of mineralographic methods in the rational analysis is limited in the identification of constituents of the product of fritting. M.V.C.

Separation of alumina during rational analysis according to the Kallauner-Matějka method. K. PFEFFERKORN AND J. BODEN. *Sprechsaal*, **70** [13] 171–72 (1937).—The method of Kallauner and Matějka usually yields too low alumina values because not all $Al(OH)_3$ is separated with NH_3 due to the fact that an "after-separation" occurs in the filtrate hours or even days later. The authors recommended, therefore, letting the filtrate rest for two days and determining the after-separation in the filtrate or using the iodide-iodate method of Stock in which no after-separation is observed. The Stock method yields higher values. It is advisable to treat the sample with a 12% HCl solution, to determine alumina in the filtrate according to Stock and, when computing, to bear in mind the clay substance. M.V.C.

Silicate–water systems. "Osmotic pressure" of silicate melts. ROY W. GORANSON. *Amer. Mineralogist*, **22** [5] 485–90 (1937).—The problem of determining the solubility of water in silicate melts when the hydrostatic pressure is not the same on the two phases is treated thermodynamically. The relation of this problem to volcanism and certain phases of igneous activity is pointed out. F.J.Z.

Sillimanite-mullite problem. W. EITEL. *Ber. Deut. Keram. Ges.*, **18** [1] 2–11 (1937).—E. reviews the work of various investigators on the Al_2O_3–SiO_2 system, crystal structure of various compounds, mixed crystals, and X-ray diffraction patterns of complex compounds, with particular emphasis on their findings with regard to sillimanite and mullite. It is shown that the formula $3Al_2O_3 \cdot 2SiO_2$ is not always truly representative of the compound mullite, as there is often more Al_2O_3 present than that formula indicates. It is possible for some of the units in the molecule to be displaced by similar units of another compound. E.J.V.

Simplified graphic method of determining approximate axial angle from refractive indices of biaxial minerals. H. T. U. SMITH. *Amer. Mineralogist*, **22** [5] 675–81 (1937). F.J.Z.

Spectrum of antimony in the extreme ultra-violet range. LÉON BLOCH AND EUGÈNE BLOCH. *Jour. Phys. & Radium*, **8** [6] 217–28 (1937).—The authors photographed the spectrum of Sb between 2400 and 200Å and give a complete list of all lines observed. Where the range investigated overlapped that of previous workers, excellent agreement with published results was obtained. New lines were also observed and their attribution was attempted. F.P.P.

Theoretical study of latent energy of solid solutions. JEAN CICHOCKI. *Jour. Phys. & Radium*, **8** [3] 99–102 (1937).—The energy possessed by the solute atoms corresponding to their compression work depends on their position in the solvent lattice. C. calculated this energy for Al dissolved in Cu and obtained, for simple substitution, 0.01 electron-volt, and for interstitial location, 0.33 electron volt. F.P.P.

Thermal tensions and graphic representation of firing. F. D. STAROSTIN. *Ogneupory*, **5** [2] 122–28 (1937).—The theories of Winkelmann and Schott and of Norton, dealing with the distribution of tensions in refractories, are criticized. A new method for representing tensions in a heated body is discussed. M.V.C.

Ultrafilters of silicon carbide. J. DUCLAUX AND M. AMAT. *Compt. Rend.*, **205** [5] 315–16 (1937).—Powdered silicon carbide from 0.3 to 3 microns in diameter gives excellent chemically neutral filters; the filter layers can be very thin. The ratio of volume of grains to volume of pores lies between 3 and 7 according to grain size. M.H.

Viscosity of Siemens-Martin slag. FRITZ HARTMANN. *Arch. Eisenhüttenwesen*, 10 [2] 47–52 (1937).—The viscosity of molten Siemens-Martin slag was determined according to the Margules method. The following conclusions were reached: (1) There is no simple relationship between basicity, calculated according to various methods, and viscosity of slag. The increase of the silica, alumina, manganous oxide, lime, and ferrous oxide content during melting sometimes increased and sometimes lowered viscosity. (2) Fluorspar liquefied slag but lowered the temperature span between high and low viscosity of the so-called viscosity range. (3) Strontianite greatly liquefied acid slag. (4) An increase of the alumina content up to 10% had no effect on liquefaction. The liquefaction observed when adding bauxite is due to the increase in the iron oxide content and not to that of alumina. (5) With increased ferric or ferrous oxide content, viscosity at first increased; then the slag liquefied. M.V.C.

X-ray determination of lattice constants and axial ratios of crystals belonging to the oblique systems. M. J. BUERGER. *Amer. Mineralogist*, 22 [5] 416–35 (1937).—A brief systematic discussion of the determination of all the lattice constants of crystals belonging to the oblique system is given. New developments are the attainment of (*a*) precision in the determination of linear lattice constants with the rotating crystal technique, (*b*) relative precision in the determination of angular lattice constants by the method of dome effects, and (*c*) high precision in the determination of angular lattice constants by the method of triangulation. The problem of the determination of all lattice constants with one crystal setting is also discussed. F.J.Z.

X-rays and gamma rays, their industrial application. T. A. TRIPLETT. *S. A. E. Jour.*, **40**, 122–27 (1937).—X-rays are readily adapted to problems in chemical analysis and crystal formation. They are effective in identifying minute particles that can not be segregated and in making radiographs, which give a picture of the inside of an object and show up various flaws. W.D.F.

BOOKS AND CIRCULAR

Alignment charts, their construction and use. P. N. LEHOCZKY. *Ohio State Univ. Eng. Expt. Sta. Circ.*, No. 34, 62 pp. (Nov., 1936).—L. describes the construction of alignment charts or nomograms to lessen the work of repetitive calculations. These can be drawn for equations involving addition, subtraction, multiplication, powers, and roots. W.D.F.

Industrial Chemical Calculations. Application of Physico-Chemical Principles and Data to Problems of Industry. O. A. HOUGEN AND K. M. WATSON. John Wiley and Sons, Inc., New York. 2nd ed. 487 pp. Price $4.50. Reviewed in *Jour. Amer. Chem. Soc.*, **58** [9] 1827 (1936). F.G.H.

Properties of Matter. F. C. CHAMPION AND N. DAVY. Blackie and Sons, London, 1936. 296 pp. Price 15s. Reviewed in *Trans. Faraday Soc.*, **33** [2] 354 (1937).—The main headings of the book are as follows: units and dimensions, *g* and *G*, elasticity, surface films, kinetic theory, osmotic pressure, diffusion, viscosity, and the determination of Planck's constant. The book is well produced and fills a gap in physics. G.R.S.

PATENTS

Attacking water-insoluble titaniferous material. J. E. BOOGE, I. J. KRCHMA, AND R. M. MCKINNEY (E. I. du Pont de Nemours & Co.). U. S. 2,098,026, Nov. 2, 1937 (Nov. 23, 1935).

Ball mill attack of titaniferous ores. F. H. MCBERTY (E. I. du Pont de Nemours & Co.). U. S. 2,098,054, Nov. 2, 1937 (Nov. 23, 1935).

Borate compound and method of preparing. H. B. SUCHR (American Potash & Chemical Corp.). U. S. 2,096,266, Oct. 19, 1937 (Feb. 8, 1935). A new product comprises a sodium borate compound resulting from the crystallization from solution of a sodium borate with water of hydration, in which the ratio of Na_2O to B_2O_3 is substantially 3:8.

Obtaining MgO and $CaCO_3$ from dolomitic material. AMERICAN ZINC, LEAD, & SMELTING CO. Brit. 471,234, Sept. 15, 1937 (Dec. 11, 1935).

Preparing potassium pentaborate. W. A. GALE (American Potash & Chemical Corp.). U. S. 2,094,881, Oct. 5, 1937 (Oct. 18, 1935). The process of producing potassium pentaborate comprises reacting a solution containing potassium pentaborate and at least 35 moles of Na_2Cl_2 per 1000 moles of H_2O with potassium chloride, boric acid, and a sodium borate more basic than sodium pentaborate, the proportions of boric acid and sodium borate being such as will form sodium pentaborate and the proportion of potassium chloride being substantially equivalent to the sodium pentaborate, and crystallizing potassium pentaborate octohydrate from the reaction mixture, the quantities of potassium chloride, boric acid, and sodium borate being less than will cause the sodium chloride saturation value in the mother liquor to be exceeded.

Producing titanium dioxide. R. H. MONK AND A. S. ROSS (American Zinc, Lead, & Smelting Co.). Can. 368,900, Sept. 28, 1937 (June 29, 1935). See *Ceram. Abs.*, 15 [4] 135 (1936).

Pug mill attack of titaniferous ores. F. H. MCBERTY (E. I. du Pont de Nemours & Co.). U. S. 2,098,055, Nov. 2, 1937 (Nov. 23, 1935).

Recovering soluble titanium compounds from titaniferous ores. J. E. BOOGE, I. J. KRCHMA, AND R. M. MCKINNEY (E. I. du Pont de Nemours & Co.). U. S. 2,098,025, Nov. 2, 1937 (Nov. 23, 1935).

Titanium dioxide processing method. R. H. MONK AND A. S. ROSS (American Zinc, Lead & Refining Co.). Can. 368,941, Sept. 28, 1937 (Oct. 12, 1935; in U. S., Nov. 5, 1934). G.M.H.

Treating hydrous borate minerals. F. W. CORKILL (Pacific Coast Borax Co.). U. S. 2,097,411, Oct. 26, 1937 (June 6, 1932).

Utilization of waste products in manufacture of titanium compounds from titanium ores. F. H. MCBERTY (E. I. du Pont de Nemours & Co.). U. S. 2,098,056, Nov. 2, 1937 (Feb. 15, 1936).

General

Aluminum a possible aid in reducing silicosis. J. J. DENNY, W. D. ROBSON, AND D. A. IRWIN. *Eng. Mining Jour.*, **138** [9] 47–50 (1937).—The authors point out as basic facts established by other investigators (*a*) that chemical reaction and not the physical presence of siliceous material is responsible for the fibrosis produced in silicosis and (*b*) that tissue reaction to quartz is proportional to particle size, *i.e.*, 1 to 3 micron particles produce acute fibrosis where 10 to 12 micron particles produce only foreign body reaction. Dangerous silica particles are under 5 microns. Working from these facts, the technique and results of a series of solubility experiments in beakers and of a series of animal experiments are described. Small quantities of metallic aluminum dust almost completely inhibit the solubility of siliceous material in the beaker. Seven rabbits dusted with quartz to which less than 1% of metallic aluminum dust had been added showed no fibrosis. Six control rabbits dusted with quartz only showed well-developed silicosis. Solubility of quartz is increased by the presence of small amounts of the carbonates and hydroxides of magnesium, sodium, potassium, and calcium. Solubility of quartz is reduced by large amounts of calcium hydroxide but is entirely dependent on the strongly alkaline reaction. Two figures, 7 solubility tables. J.L.G.

Automatic combustion control for furnaces and boilers improved. E. W. WAGENSEIL. *Steel*, **98**, 54, 65 (Feb. 17, 1936).—Improvement in design and efficiency of modern automatic combustion-control equipment has improved the quality of the product and effected a saving in fuel costs. Automatic combustion control on six stoker-fired boilers resulted in a saving of 5% of the fuel costs. Combustion control is particularly needed where fuels such as blast-furnace gas, coke-oven gas, or coke breeze are burned. H.E.S.

Canadian ceramic industry (a statistical review). W. H. LOSEE. *Jour. Can. Ceram. Soc.*, **6**, 32–34 (1937).—L. deals with the production of clay products from (1) domestic clay and (2) imported clays. J.G.P.

Ceramic industry in central Brazil. K. ENDELL. *Ber. Deut. Keram. Ges.*, **18** [1] 35–37 (1937).—A brief discussion of the ceramic industry in central Brazil, consisting of the districts of Rio, São Paulo, and a part of Minas, is presented. The coals found in this district are high in ash content and sulfur and so are not the best for ceramic firing. Among ceramic raw materials found here are kaolin, refractory clays, shale, bauxite, zirconium oxide, quartzite, and chalcedony. Some of the plants visited and their products are described. E.J.V.

Collation of experimental data: 42. A. ALISON. *Glass*, **14** [3] 96–98 (1937). **43.** *Ibid.*, [4] 144.—The use and the interpretation of the moving average are discussed. The moving average is not as adaptable nor as easily checked as the arithmetical average. **44.** *Ibid.*, [5] 195.—A. discusses the effects of short time fluctuations and methods of eliminating this disturbing factor in studies covering long periods. **45.** *Ibid.*, [6] 239.—The use of the coefficient of correlation for studies covering long periods is illustrated. For Parts **39–40** see *Ceram. Abs.*, **16** [9] 288 (1937). M.C.S.

Engineering as a career. FRED P. PETERS. *Metals & Alloys*, **8** [8] 235–36 (1937).—P. discusses the engineer as an executive, engineering education, salaries, and industrial opportunities. He concludes that at present engineering offers at least as attractive a career as other professions and that, with the current trend in engineering education, the future for engineers should be even brighter. F.P.P.

Engineering design applied to dust elimination. ANON. Report of Engineering Control Subcommittee to the National Silicosis Conference; abstracted in *Concrete, Cement Mill Ed.*, **45**, 203–204 (1937).—The importance is shown of good housekeeping in keeping the buildings and machinery free from settled dust, in collecting the dust, and in ventilating by properly designed hoods, piping, air cleaners, and fans. The work must be properly supervised, and the results must be tested carefully and frequently. W.D.

Examination of precious stones. J. BOLMAN. [illegible] *Weekblad*, **34** [29] 496–501 (1937).—The methods developed in the Nederlandsch Instituut for the scientific investigation of precious stones are described. The different behaviors of genuine and synthetic stones are compared in tables giving color, hardness, specific weight, refractive index, and conditions of luminescence. M.H.

From open-pit to underground mining. S. G. CHIPMAN. *Can. Mining Jour.*, **58** [9] 478–82 (1937).—In 1936, Canadian Refractories, Ltd., found it necessary, owing to increased amount of stripping and scaling, to change to underground mining of magnesite. A 420-ft. shaft was sunk and three levels were established; the magnesite is mined by shrinkage stoping. The program of mine development is outlined. In addition to making available hitherto inaccessible ore, underground mining has resulted in lowered costs by making possible year-round operation, continuous supply of ore, more efficient workmen, less men per ton mined, elimination of hand mucking, and better selection. G.M.H.

Insulating furnace saves fuel. WYO-LITE INSULATING PRODUCTS. *Steel*, **98**, 54 (Feb. 10, 1936).—Application of 4 in. of insulation on the roof of an annealing furnace for iron tubes has reduced the start-up time 2 hr., the fuel consumption 34%, and cold spots in the furnace. Natural gas is fired in the side muffles, seven burners being used per side. Savings in the quantity of gas used and start-up labor amounted to $20.24/day. The insulation paid for itself in 19.3 days. H.E.S.

Keep it clean. R. BALL. *Excavating Engr.*, **31**, 507–11 (1937).—The Ball Clay Co. (near Gleason, Tenn.) has a deposit of high-grade clay 3 to 6 ft. thick. Over this are 2 ft. of lignite and 60 ft. of sandy overburden. Very particular care must be taken to avoid contamination. The overburden is handled by power shovels on three benches; the clay is uncovered in long, narrow blocks only as needed. The lignite is stripped and thrown against the overburden bank where it prevents the sand washing down. When loading, a power shovel peels slices off the full height of the deposit. The clay is hauled in trucks with dustproof bodies, stored in concrete sheds lined with waterproof paper, disintegrated and picked

over before final loading, and loaded into carefully cleaned cars. The bill of lading is stamped "Do not transfer". W.D.F.

Liquid films between seized surfaces. J. M. MACAULAY. *Jour. Roy. Tech. Coll.* [Glasgow], **4** (Part 1), 12–21 (1937).—Previous work ("Seizure of Surfaces," *ibid.*, p. 353 (1935)) has been extended to include surfaces contaminated with two engine oils, aniline oil, and caproic acid. The forces varied as the distance squared between surfaces. A large increase of tangential and normal seizure forces was measured for thin water film between glass plates, and the results are discussed. Tests on glass and mica surfaces for distortion due to water films are described. W.H.B.

Mineral substances capable of producing silicosis. B. GOSSNER. *Arbeitsschutz*, **1936**, No. 9, pp. 234–37; abstracted in *Chimie & Industrie*, **37** [5] 895; see *Ceram. Abs.*, **16** [5] 164 (1937).

Mississippi clay investigations. W. C. MORSE, G. H. WOOLLETT, AND V. A. COULTER. *Bull. Amer. Ceram. Soc.*, **16** [11] 450–51 (1937).

Owens-Illinois Glass Company dedicates research laboratory. ANON. *Bull. Amer. Ceram. Soc.*, **16** [11] 454–55 (1937).

Preparation of German feldspar ore by flotation and magnetic separation. G. GERTH. *Ber. Deut. Keram. Ges.*, **17** [10] 526–34 (1936).—G. describes tests made on synthetic mixes of feldspar and biotite, using as a flotation medium a mixture of 4 kg. sodium oleate and 1 kg. phenol per ton of material to be separated. This method resulted in a feldspar-quartz product which melted to a pure white with no dark spots. G. points out variations in the flotation media, showing how German feldspathic ores were separated with different types of flotation media. Magnetic separation can be employed where the original ores are pegmatitic or contain magnetic minerals as the dark portions. G. suggests that the best results can be obtained by following a magnetic separation with a flotation process. E.J.V.

Properties of melted clays. V. M. TSYNKINA. *Ogneupory*, **5** [2] 128–34 (1937).—The properties of a series of melted clays and kaolins were studied. All these materials contained about 50% mullite; their refractoriness and deformation temperature under load were increased, and their resistance to the corroding action of molten glass was considerable. The mullite content of melted clays may be increased by reducing silica into silicon and converting the latter into ferrosilicon. M.V.C.

Sixth national ceramic exhibition. ANON. *Bull. Amer. Ceram. Soc.*, **16** [11] 444 (1937).

Testing materials by colored light. W. KIRCHER. *Ver. deut. Elektrotech. Fachberichte*, **8**, 118–20 (1936); abstracted in *Physik. Ber.*, **18** [16] 1493–94 (1937).—By using colored light instead of white light for the illumination of work places (by metal vapor lamps), it is often possible to detect defects much easier. With the entrance side of a tempering furnace lighted with mercury-vapor lamps and the delivery side lighted with sodium-vapor lamps, fine cracks in the tempered glass, which are otherwise hardly visible, show very clearly. Other applications in the metal industry are mentioned. M.H.

Wetting of mine dusts. A. M. BRYAN AND J. SMELLIE. *Jour. Roy. Tech. Coll.* [Glasgow], **4** (Part 1), 178–87 (1937).—The authors investigated the ease of wetting of coal and stone dusts with water and dilute solutions of Perminal W, a textile wetting agent. $CaCl_2$, for its hygroscopic effect, and Perminal W, for its binding effect, can be used together as a more effective treatment. The results of tests for a variety of dusts are given in curves and tables. W.H.B.

Winning ceramic clays by blasting. FRIEDRICH WEICHELT. *Ber. Deut. Keram. Ges.*, **17** [4] 196–204 (1936).—W., a blasting engineer, discusses proper and improper methods of obtaining ceramic clays by blasting in strata. Illustrated. E.J.V.

BOOK AND CIRCULARS

Application of Statistical Methods to Industrial Standardization and Quality Control. E. S. PEARSON. British Standards Inst., London, 1937. 161 pp. Price 5s. Reviewed in *Jour. Textile Inst.*, **28**, 99–100 (1937). H.H.S.

Dust hazards and their control in mining. D. HARRINGTON. *U. S. Bur. Mines Information Circ.*, No. 6954, 7 pp. Free. Dust hazards, especially in metal mines, are discussed. R.A.H.

Protection against mine gases. J. J. FORBES AND G. W. GROVE. *U. S. Bur. Mines Miners' Circ.*, No. 35, 52 pp. Price 10¢. This circular is a revision of an earlier circular. It discusses the erection of barricades during mine fires or following mine explosions, the construction of refuge chambers, the carbon monoxide self-rescuer, gas masks, oxygen breathing apparatus, and resuscitation. R.A.H.

Results of first-aid training of all employees of a mine or plant. J. J. FORBES. *U. S. Bur. Mines Information Circ.*, No. 6957, 13 pp. Free. F. outlines the Bureau's first-aid course, tabulates the number of men trained, by years, and gives instances of the value of training supplied by mine officials. R.A.H.

PATENTS

Ceramic manufacture. W. K. CARTER AND G. H. DUNCOMBE (National Aluminate Corp.). Can. 369,507, Oct. 26, 1937 (Sept. 17, 1936; in U. S., Sept. 20, 1935). The process of improving the working characteristics of ceramic raw materials comprises tempering them with water whose surface tension has been reduced to 55 dynes/cm. by the addition of lauryl sulfate or other substance. G.M.H.

Colored mineral granules. C. E. HILLERS (Blue Ridge Slate Corp.). U. S. 2,094,452, Sept. 28, 1937 (Aug. 20, 1935). The process of producing green-colored, nonglossy coatings on granules involves (1) applying sodium silicate, chrome oxide, and a reducing agent to granules and mixing; (2) applying powdered aluminum sulfate and mixing; (3) heating to a temperature of from 1600° to 1900°F; and (4) cooling the granules.

Making granules. C. L. COLBERT (Empire Trust Co.). U. S. 2,093,998, Sept. 28, 1937 (April 21, 1932). A method of making granular materials comprises reducing a compact argillaceous material, subject to hardening by heat, to the desired size or range of sizes, treating it with a softening agent in dilute solution, drying to disperse a thin coating

upon the granule surfaces, heating to harden the granules and to render the softening agent effective upon the treated surfaces, mixing the granules with refractory coloring materials in finely comminuted condition, and heating to a temperature sufficient to soften the treated surfaces.

Pervious body for acoustic, etc., purposes. E. T. HERMANN. U. S. 2,095,252, Oct. 12, 1937 (April 6, 1931; renewed Jan. 15, 1937). An integral body formed of a plurality of intercontacting supportingly interbonded elongated strands formed of inorganic material selected from the group consisting of ceramic and cementitious materials, providing a high percentage of mutually intercommunicating voids therebetween, the elongated strands having a cross-sectional configuration characterized by at least a portion thereof tapering to a relatively thin edge portion, and the strands being interbonded at the relatively thin edge portions.

Producing insulating material. G. R. HOOVER AND M. M. HOOVER. U. S. 2,096,398, Oct. 19, 1937 (Feb. 5, 1936). The method of producing a porous material comprises adding a fermentation-producing agent to an aqueous intimate dispersion of a bituminous material in clay to effect an aëration of the material and drying the material in its at least partially aërated state.

Silicate surface coatings. N. PAL AND PALSALES, LTD. Brit. 473,513, Oct. 27, 1937 (Nov. 18, 1936).

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January 20, 1937	1478	199				
February 23, 1937	1579	210	19	515	220	2543
March 29, 1937	1613	212	18	524	220	2587
April 23, 1937	1517	209	29	485	220	2460
May 22, 1937	1541	209	25	501	220	2496
June 22, 1937	1572	211	23	502	220	2528
July 20, 1937	1607	212	20	506	220	2565
August 23, 1937	1634	215	17	509	220	2595
September 23, 1937	1647	217	19	509	220	2612
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Mineral Industry
Mineral'noe Syr'e
Mining Journal (Phoenix, Ariz.)
Mitt. Forschungsinst für Electro-Wärmetech (Hannover)
Mon. Phys. Phys.-Chem. Glass (Moscow)
Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen, Jahresbericht über das Geschäftsjahr, Mathematischphysikalische Klasse
National Physical Laboratory, Collected Researches, Report
Natuurwetenschappelijk Tijdschrift
Nauchnye Zapiski po Sakharnoĭ Promyshlennosti
Nitrocellulose
Nova Acta Leopoldina
Paint Manufacture
Paint, Oil & Chemical Review
Periodico di Mineralogia (Rome)
Petroleum Engineer
Philippine Journal of Science
Proceedings of the Royal Academy of Sciences of Amsterdam
Proc. Highway Research Board
Proc. Imperial Academy [Tokyo]
Proceedings of the Iowa Academy of Science
Proc. Staffordshire Iron & Steel Institute
Przemysl Chemiczny
Pub. Nat. Bur. Econ. Research, Inc.
Refrigerating Engineering
Reichsarb.-Bl.
Repts. Imp. Ceram. Expt. Inst.
Reports of the Imperial Industrial Research Institute, Osaka, Japan
Revue de Métallurgie
Roczniki Chemji
Russko-Germanskiĭ Vestnik Nauki i Tekhniki
Schweizer Brauerei Rundschau
Science News Letter
Sitzungberichte der Akademie der Wissenschaften in Wien, Mathematische-Naturwissenschaftliche Klasse.
Soap
Stahl und Eisen
Steam Engineer
Stone
Sveriges Geol. unders
Technische Blätter
Technisches Gemeindeblatt
Teknisk Tidskrift
Teknisk Ukeblad
Tonindustrie-Zeitung